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A Lock Canal at Panama.

A large majority of the House of Representatives at Washington has voted for the plan of lock canal proposed by the minority of the Board of Consulting Engineers, while the Senate by a close vote has expressed the same judgment. This settles the type for the proposed Isthmian Canal for the present. The Engineering Record has advocated the adoption of the sea level canal for a number of reasons. In the first place, the President appointed an international Board of Engineers, the eminence and qualifications of whose members have never been excelled by any group of engineers convened to express judgment upon any great project, and the verdict of a substantial majority of that Board was in favor of a sea-level canal. There has as yet been assigned no sufficient reason for setting aside the deliberately formed professional judgment of that Board. The appeals to national prejudice, both in Congress and out of it, in the discussion of this great question, have been narrow, misleading and most unfortunate. The position taken by The Engineering Record has been one of open-mindedness until the evidence was completed, and it has no sympathy for any resort to prejudice, either local or national, to strengthen a cause intrinsically weak. This journal has stood for a conclusion of this great question based upon a fair and drastic consideration of all proper evidence bearing upon it for the sole purpose of reaching such an issue as will best serve the interests of this country.

In the second place, it has seemed sufficiently clear to an engineering judgment unbiased by predilection for special features or structures which might be incorporated in a canal, that an open, continuous and unobstructed waterway at sea level between the two oceans at the Isthmus of Panama was the best possible Isthmian Ship Canal; and no evidence or agreement has yet been set forth to militate in any degree against the obvious validity of that common-sense proposition, although a wealth of ingenious, finely drawn arguments have been laboriously developed to show the comparatively harmless character of the dangers and difficulties resulting from the passage of great ships through locks, single, or in series, and of the navigation of submerged channels, all, as demonstrated by actual experience in existing canals, to say nothing of the problematical character of other structures proposed to be built, in violation of the soundest engineering principles.

If the lock canal can best serve the interests of interoceanic navigation at the Isthmus, then unquestionably such a canal should be built; but if that is the case there should be a demonstration of it upon evidence. As a matter of fact, the question of the type of the Isthmian Canal has not been settled upon its merits in Congress. The final decision, as expressed by the votes of both Houses, was affected by a number of remarkable features far from the nature of evidence.

The decision of a great technical question by a body of laymen, even if they are eminent as statesmen, involves grave hazard, amounting to almost certain miscarriage. The way is open to the entrance and recognition of grotesquely or intentionally erroneous evidence on the same plane with that of the highest character. There is about as little probability of reaching a proper conclusion as if the question were referred to a popular vote. Again, any great national project reaching Congress cannot possibly escape political pressure in one shape or another. Indeed, it has been correctly stated in Washington ever since the subject of the Isthmian Canal reached the Senate Committee on Interoceanic Canals that great pressure was being exerted to secure the adoption of a lock plan in any event, and essentially as much was said in the speeches made in both Houses.

There probably has never before been such an extraordinary and even grotesque misapplication of argument on a great public question in Congress, accepted as effective for the very features of a plan which it conclusively condemns. One instance of this kind may properly be cited. Representative Burton's speech in the House was considered most effective in favor of the lock plan. In the trend of his argument for the security of ships passing through locks, he cited the relative safety of the lock at the Soo as compared with the dangers to ships in the submerged channels of St. Mary's River and the St. Clair Flats. Mr. Burton stated that these "channels 300 ft. wide or more" have a record during the past fifty years of "a long list of disasters arising from collisions, from grounding, and, perhaps worst of all, as the result of boats being driven athwart the channel. By these accidents shipping has been delayed many days, with the result that the damage to boats upon the Great Lakes has assumed very large proportions." When it is remembered that lake channels with submerged banks precisely like those of St. Mary's River and the St. Clair Flats, and largely of the same dimensions, constitute the main feature (exclusive of the locks admitted to be too small as well as dangerous to large ships) of the proposed Isthmian Lock Canal, it is curiously obvious that Representative Burton himself has conclusively, though unintentionally condemned what the minority of the Consulting Board put forth as the saving feature of its plan.

Finally, the House Committee declined to secure any technical evidence from the Consulting Board, or from any other quarter, for its information, save from the Chief Engineer of the Canal Commission, and that testimony was probably as remarkable in a number of ways as any that ever proceeded from the engineering head of a great public work.

A decision upon the main central feature of such a great continuing public work should be reached upon its merits, and upon its merits only. The fundamental elements of the congressional verdict on the type of the Isthmian ship waterway indicates incipient disintegration. The final conclusion of the matter has not yet been reached. The Isthmian Canal Commission is charged with a great responsibility, not made lighter by recent events; but an open field is before it in which it is reported to be "cut loose." The future must show the results.

The Bishop's Creek Power Plant.

Long-distance power transmission from electric generating stations is now so common that it takes more than a mere new installation to justify comment. The plant of the Nevada Power, Mining & Milling Co., described in this issue, is, however, of unusual interest as embodying some rather advanced ideas, as well as by reason of the unusual length of the line for so moderate an output. The transmission in this case forms another addition to what one may call the 100-mile class, extending in fact to 113 miles. The present capacity is only 3,000 k.w., an amount of power which, until very recently, would have been considered too small to transmit profitably so great a distance. The line itself is of rather striking design. It is an excellent example of long-span construction, the normal distance between poles being 310 ft.—a scant 17 poles per mile. The poles are mainly of Oregon cedar, and the single current carried on one cross arm and a pole-top, 6 ft. apart on centers, is of stranded aluminum. The construction of pole lines has so long been dominated by ancient telegraph practice that the advantage of long-span construction has been kept in the background until recently. The design of pole lines as strain-supporting structures to be laid out along strictly mechanical lines has led to the not very astounding discovery that a well set and substantial pole will carry a single light circuit, such as is used at high voltage, with long spans, while still retaining an adequate factor of safety.

The result is a singularly cheap and effective line, with a greatly reduced number of insulators to serve as leakage points and a correspondingly decreased chance of breaking down. Another interesting feature of the system is the independent telephone line carried on poles of its own. The inductive disturbances are greatly reduced by this change, although it might be questioned whether it would not have been cheaper and quite as effective to have put some extra expense in insulation and careful transposition. Perhaps the immunity from high-tension crosses gained in case of storms may be abundant justification. The hydraulic plant is rather unusual in the large amount of wooden stave pipe employed—12,000 ft. in all. Such pipe is rarely used in the East, although some old examples are to be found in New England and in a few recent supply lines for water distrbution systems. In the former case the staves were of Oregan fir 2 in. thick, milled to shape and assembled on the ground, as such pipe always is, with hoops of ½-in. mild steel spaced on 6-in. centers. For cases where transportation of material is difficult, stave pipe is exceptionally convenient, and from long experience has been shown to be trustworthy. Under favorable conditions, too, it is somewhat cheaper than steel, which is an added advantage. The wooden pipe is used in 30-in. diameter up to a static head of 265 ft., and then is replaced by steel pipe up to the total head of 1,068 ft. It seems probable that the pressure mentioned is one, at least, of the very highest regularly carried in wooden-stave pipe. The pipe was put together with great rapidity, the rate of 110 ft. per day being maintained for two months. In fact, the whole plant was rapidly constructed, current being turned on in less than seven months from the beginning of active operations.

The electrical equipment of the system presents no remarkable features, and the line voltage, 30,000 volts, is at present moderate, although this may be transposed to star-connection later. While plants designed for operation at 60,000 volts and upwards, are frequently built, it must be remarked that few, if any, are actually in daily operation at this figure. The vital question at high voltage is an adequate factor of safety in the insulators, which seems very difficult to secure as yet. As insulators are now ordinarily rated, the factor of safety as between working voltage and testing voltage is about 2.5 and sometimes less, which is hardly enough for safety. Until improvements are made practice is likely to advance rather in the increasing number of plants at fairly high voltage than in the increase of the maximum now existing.

Bridging the Mississippi at Baton Rouge.

The renewal of the project of bridging the Mississippi River at a crossing near enough to the Gulf to serve the purpose of railroads converging in Louisiana and Mississippi, appears likely to result in the construction of a railroad bridge at Baton Rouge. Ten or a dozen years ago New Orleans seemed to be the favorite crossing, perhaps, chiefly for the reason that the Southern Pacific Railroad interests then dominated the project. Although the great railroad interests centering at New Orleans apparently fixed the location of a bridge there at that time, the inherent difficulties of that crossing were sufficient to prevent the culmination of the enterprise. The low, flat country on both sides of the river at New Orleans and the magnitude of the navigation interests, the latter compelling a comparatively high-level bridge, so enhanced the cost of the necessary approaches that the proposition never even closely reached realization. The advantages of a railroad crossing over the river, giving uninterrupted transportation, were sufficiently obvious to result in the preparation of complete plans and specifications, but little else.

There is, however, an inherent need of unbroken train service across the river, and little doubt exists that it will be attained in the comparatively near future. The Baton Rouge site has a number of advantages over the New Orleans location, and probably few disadvantages. In the first place, more elevated ground on one side of the river forms to a certain extent a natural approach, and the other side is certainly as good as either side at New Orleans. Again, the shipping, which would be more or less inconvenienced by a bridge crossing, is much less in amount at the upper location. Indeed, it may be a question whether it is necessary to consider at this point more than a low-level bridge with a draw. In any event, the physical features of the situation are far more encouraging than at the lower site.

A glance at the map of the two States of Louisiana and Mississippi will show that lines of through railroad transportation will be served about as well, as far as distances are concerned, by the upper crossing. There is always an obvious advantage in making even through lines of transportation tributary to great business centers, and New Orleans would certainly serve this class of requirements better than Baton Rouge; but this is probably not a consideration of the highest importance in this particular instance. Should a bridge be built at the new proposed location some additional short railroad lines will be required to reach it, but this construction would not be sufficient in amount to prove serious.

One of the important elements of any project in the Mississippi Valley bearing upon the larger problems of transportation is its effect upon the foreign business of the port of New Orleans, which is becoming a shipping point of great consequence to the Southwest. Any "tool" of transportation which is likely to affect favorably the shipping interests of that city will certainly receive most serious consideration, and will be likely to materialize. It is difficult to see why a railroad bridge at Baton Rouge would not be in position to serve this class of interests about as well as if it were at the city of New Orleans itself. Even Southern Pacific freight from the West would reach the New Orleans terminals about as advantageously in every way via a Baton Rouge bridge as by its present line and ferry. And the same general observation will apply to any freight reaching this port along lines west of the Mississippi River.

The substantial progress made in the broad field of both superstructure and substructure building during the past ten or twenty years makes the project of bridging great rivers, even with the soft substrata of the lower Mississippi Valley, much less formidable than would have been the case even ten years ago, when the older New Orleans project was being agitated. When this fact is coupled with the comparative ease with which capital for the greatest transportation projects can now be secured, the demand for a railroad bridge crossing on the lower reaches of the Mississippi River suitable to serve the great railroad lines converging at New Orleans, appears most reasonable and most likely to receive a favorable response.

Underpinning Heavy Buildings.

The great increase within a few years of the number and magnitude of engineering constructions in the largest American cities has produced a very interesting and important secondary result in the necessity arising for underpinning many tall and heavy buildings. Some examples exist, or may exist in most of the principal cities, but they are numerous only in those localities where the three following important conditions, at least, are combined: Deep, treacherous soil, very heavy existing buildings, and deeper excavations for new work than the adjoining foundations. The last two elements are generally furnished by tall steel-cage buildings and by the construction of foundation pits for heavy loads that must be carried to considerable depths by the construction of deep trenches, and by tunneling under the streets.

Comparatively few cities have many tall steel-cage buildings; of the few which have them, several have solid dry soil, or rock well suited for heavy foundation work and few have as yet important systems of trenching or tunneling near the tall buildings. In Boston where extensive subways have been constructed the soil is comparatively good, but in New York and Chicago, extensive systems of subway and tunnel excavation have been made and are in progress through the districts containing great numbers of extremely heavy buildings.

In these greatest two American cities there is much congestion and the resulting high value of space has naturally caused the construction of much larger numbers of very tall buildings than can be found elsewhere. These buildings concentrate enormous loads on their foundation piers when they are of the skeleton type of construction, and those of more moderate height which have self-sustaining masonry walls are yet tall enough to bring heavy pressures on their footings. In New York most of these buildings are located in a territory where the solid rock is overlaid with from 30 to 60 ft. of quicksand, or fine sand, gravel and fill saturated with ground water for many feet above the bed rock. In Chicago, a thin layer of loam, or fill is supported on a crust of hard clay a few feet thick under which there is 60 ft. or more of very soft plastic clay overlying hardpan and rock.

In New York only a score or two of the latest and highest buildings have been built with concrete foundations carried below water level to rock by the costly pneumatic caisson method; the others have pile, grillage or extended masonry foundations. When adequate, pile foundations may be carried by the rock or other sufficiently solid and unyielding strata. They are, of course, reliable, when permanently saturated, but grillages or masonry footings seated on the earth or sand, unless the latter is confined or undisturbed, are likely to prove insecure if adjacent excavations are carried below them. In Chicago some foundations have piles or concrete piers carried down to hardpan or to rock. A great number of important buildings in that city are, however, built on footings made with steel and concrete grillages distributing the loads so as to get moderate pressure over large areas of the upper clay crust. These have at best, settled materially and many of them are liable to serious and irregular settlement, or undermining when deep excavations are made near them.

The present tendency in both New York and Chicago, is to carry the foundations of tall buildings to the deep solid strata and the excavations for them as well as those for the lines of subway and tunnel work cause danger of undermining and settlement to shallow foundations. As most of the buildings contain heavy engines, dynamos, hydraulic machinery, systems of gas and water pipe, and delicate elevator mechanism which must be maintained in perfect alignment, even a small settlement is extremely serious aside from the damage to the building and the visible cracks and fractures. It is therefore often necessary to provide in advance for the stability of the buildings before new construction is undertaken near them. Although the work thus involved is very heavy, it is at the same time delicate and sometimes critical, and has developed into a distinct class of engineering operations involving unusual skill and experience and many special methods and appliances.

Most of the principles involved in underpinning are simple and well understood, but they have been combined very ingeniously and have been extended to operations of great magnitude as described in many articles published in this journal, such as those relating to the Decker Building, Bank of the State of New York, the Postal Telegraph Building, Empire Building, Marshall Field Building, and a large number of others. The availability of single and double tiers of deep steel I-beams makes it possible to carry tall and heavy walls on long-span needle-beams, permitting free access underneath them for excavating and building. Solid reactions are sometimes obtained by sinking preliminary pits to hard stratum and building special concrete piers in them to carry the loads temporarily, but in Chicago the present practice is to carry the loads on cribbing built up on the clay. Elaborate work has been done in shifting the loads of the long heavy walls from needle-beams to longitudinal girders in the planes of the walls and thus affording wide, unobstructed working spaces. Buildings have been supported on yielding soil, by needle-beams which were continually jacked up to maintain their level, while ground was lost under them until finally stability was secured. Where one side of the wall was inaccessible ingenious devices have been adopted to support it wholly from the other side by various means including the figure 4 needle-beam and cantilever needles heavily counterweighted, or reacting against the floorbeams of the building itself. A notable advance in underpinning methods has been made by the adoption of cylinder piers sunk in the plane of the walls by open or pneumatic process and supporting the building without in any way obstructing its interior or temporarily reducing its stability. In some cases, heavy walls have been of such poor quality that careful reinforcement was requisite before they could be underpinned.

In Chicago nearly a score of important buildings are now being underpinned on account of the settlement due to undermining produced by adjacent excavation. Only a portion of this settlement, if any, can be attributable to the system of freight tunnels recently constructed near these buildings. Much of it is due to obvious subterranean flow of the plastic clay, as is illustrated in the recent excavation for a building from which it is said over 10,000 cu. yd. of spoil were removed in excess of the 40,000 cu. yd. volume of the open pit. Such movement of material has caused a subsidence in the streets in many places throughout the city. In one case the verticality of a tall building that is believed to have been affected in this manner to some extent, at least, is being restored by jacking up under two transverse rows of columns under one end of the structure so as to concentrate more of the weight of the building on the columns under the opposite end and increase the settlement at that end. When the excavations in the vicinity of this building are completed the building will be restored to its former footings. In the case of a large department store now being reconstructed by successive sections the walls of the building occupying the entire side of an adjacent block 380 ft. long are being underpinned and are now supported by cribwork and jacks which require constant adjustment to compensate for the progressive settlement.

It is thus evident that a great and increasing amount of underpinning is requisite and that it has become a very important class of engineering. The two examples illustrated in this issue of The Engineering Record, although not of the first magnitude are particularly interesting on account of the special conditions involved. In the case of the Grand Central Palace, a heavy wall of old-fashioned construction has been quickly and successfully underpinned by simple methods and plant well adapted to ordinary conditions. In the case of the department store in Albany, varying methods were adopted with suitable details for the different conditions of the old weak buildings which were taken care of prior to the undermining inevitable in the operations of building the new structure. Had corresponding precautions been taken with the building previously occupying the site before its reconstruction was commenced, the disaster which occurred there last year would have been averted.

Superheated Steam.

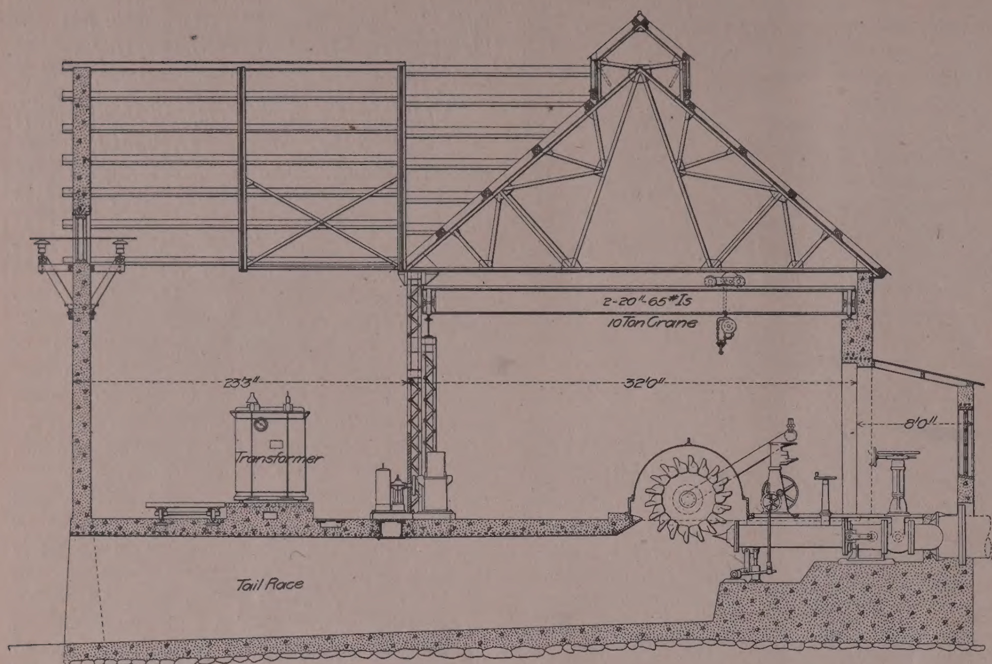
The reference in the letter of Mr. E. H. Foster, printed elswhere in this issue of The Engineering Record, to an experience with two types of boilers in the same plant, and their different effects on engine economy, recalls the days when Corliss was revolutionizing steam engineering practice. No considerable part of his business success over imitators and other competitors was due to the fact that he sold "power"—the complete steam plant, and not the engine alone. While Corliss invariably could meet his guarantees, rivals supplying only the engine and basing their faith on previous accomplishments, were often less fortunate, sometimes much to their perplexity. It is said that Corliss in the shop tests of pumping plants, which tests formed a notable feature of his practice, left indeterminate the water level in the high vertical tube boilers he employed until by a series of experiments he had fixed the level at which the steam generated produced the best engine economy, the proper tube steam surface for the best effect having been found to vary considerably even for engines approximately the same. Corliss practically, as we have just seen, and Hirn experimentally, early established the benefit of adding heat to steam after its evaporation, and at first sight it is somewhat surprising that superheating has not yet passed entirely beyond the stage of controversy. A closer examination, however, reveals the probable reasons for this.

In the first place, the term superheat is used in an ambiguous manner, being applied equally where the steam acted upon is merely dried, or even partially dried, and where the temperature of the entire admission steam is raised some hundreds of degrees. Then again, the specific causes of economy from superheat are somewhat obscure, thus giving latitude for broad claims on the one hand and for sweeping denials on the other hand. Finally, reports of tests showing economy from superheating are too apt to be open to criticism from being limited to a showing of water rate alone, not including factors such as the fuel and labor chargeable to superheat, and investment in and maintenance of apparatus, which items, of course, affect the final or commercial economy.

Leaving aside as a special case the employment of very high superheat, while in superheating the thermodynamic gain proper is so small as to be almost negligible, there seems no doubt that the fluid working economy of any engine can be more or less increased through the application of superheat, and that in cases a gain as high as 20 per cent. is possible. One of the important factors fixing the extent of the economy is the previous state of the steam acted upon in the superheater, and the neglect to consider this has doubtless been one of the causes of the differences of opinion as to the value of superheat. It is obvious that in comparing tests of an engine supplied direct from the boiler with wet steam, with tests of the same engine having a superheater between it and the boiler, a much greater increase of economy in the former case may be expected. Again, the design of the engine may affect the result, a poor engine from the fluid-working standpoint showing a greater increase in economy for a given superheat than an engine of superior design. Finally, the economy from superheat appears to increase very slowly —if at all in some cases—up to 70 deg., though beyond that point some recent experiments indicate that the benefit is directly proportional to the temperature rise.

Owing to the special character of the apparatus and the desirability of some certain means or regulation of superheat to provide for loads below the normal, and particularly for very variable loads, the adoption of high superheat is at present a question that should be decided specifically for each proposed case. Ordinary superheating, however, has on its side such an array of evidence, the accumulation of two generations, that to deny its efficacy or to neglect its application, is to put oneself in a class with the small and diminishing body which yet refuses to be convinced that the multiple expansion engine is the superior of its single cylinder prototype. On the other hand, specific claims for efficiency of superheating unaccompanied with full details as to quality of steam, type of engine, conditions of test, and complete cost data, will do little toward convincing even the open-minded doubter.

The Model Abattoir Plant described elsewhere in this issue gives a brief indication of the great advances made in the last few years in the design and construction of the various buildings connected with plants of this character. That the plant referred to is within a few blocks of the theatre and the most exclusive business district of New York City, and that it is operated with such little odor reaching its immediate and closely built-up vicinity that no offense is occasioned, are sufficient evidence that the noisome conditions usually surrounding such plants may be overcome. The structures and equipment of this plant are in many ways a departure from the usual practice followed in the design of similar work. In the first place, the design of the plant was governed to a great extent by the value of the real estate on which it is located; at the same time, it is based on the best of all the experience that has been obtained in abattoir construction and operation. One of the most notable features of the design, due to the limited area available, is the erection of a building of five stories for the abattoir, rather than the one, two or at the most, three-story structures usually erected for such buildings. The use of enameled brick for all the wall surfaces and of impermeable floors throughout the structure, except in the cooling rooms, providing an absolutely non-absorbtive finish that is readily washed, is another commendable feature in the design. The flexibility and method of controlling the hoists used in handling carcasses are of great advantage, but have been secured by simple designs. The disposal of waste meats, offal, etc., by digestion under steam pressure, in closed vessels, as employed, appears to eliminate practically the extremely vile odor usually disseminated by such processes. The direction through the furnaces of the power station of whatever foul air is produced causes any other odors to be consumed. The sanitary conditions secured throughout the plant by the construction and equipment adopted are most unusual, affording surroundings for the employes that are far above the average. The exterior of the abattoir building has, at the same time, been so treated that a most pleasing structure has resulted. Although these various features must have added appreciably to the cost of the plant, the economies obtained in operating are said to at least offset any additional outlay due to them.



Sectional Elevation through Power Plant, Nevada Power Mining & Milling Co.

THE HYDRO-ELECTRIC POWER PLANT OF THE NEVADA POWER MINING & MILLING CO.

By J. D. Galloway, M. Am. Soc. C. E., San Francisco.

The hydro-electric power plant of the Nevada Power Mining & Milling Co., which it is the purpose of this article to describe, is situated on Bishop Creek, Inyo County, Cal., about seven miles from the town of Bishop, and the transmission line extends to Goldfield and Tonopah in Nevada. The first generator was placed in operation about Sept 20, 1905, and since then power has been supplied the last-named places. The company owns the local lighting plants of the two cities and thus a portion of the load is the lighting circuits, while the balance is stamp mills and mines. While no unusual features are to be noted in the plant it is deemed of sufficient interest to warrant description.

Bishop Creek lies on the eastern slope of the Sierra Nevadas and, with the exception of Owens River, is the only considerable stream on that side of the mountains for several hundred miles. Its headwaters are in the snow of the highest part of the Sierras, which here reach an altitude of over 14,000 ft. above sea level. The plain of Bishop or the Owens River valley lies at an elevation of about 4,000 ft. The mountains rise abruptly from the plain, and the descent of the stream is correspondingly rapid. Its fall is over 1,000 ft. in two miles. This, so far as the writer knows, is the most favorable location in this respect of any power plant in the West.

Water is taken from the creek at a small diverting dam and conveyed along the mountainside in a wooden stave pipe until it reaches a point above the power house, where it enters a steel pipe that leads to the power house on the creek bank.

The transmission line extends across the valley of the Owens River, then over the White Mountain and across the Nevada Desert to Tonopah Junction 85 miles. From here the line branches to Tonopah, 18 miles, and to Goldfield, 10 miles, making the total length of line 113 miles. In crossing the White Mountains the line reaches an elevation of over 10,500 ft.

The pipe line commences at the diverting dam, there being no flume. The dam is a small concrete structure supplied with four wasteways provided with flash-boards for regulating the height of water. At the present time the supply of water is ample at all seasons of the year, but with an increase of load it is the intention to enlarge this small reservoir formed by the dam in order that it may act as a regulating reservoir. As the load factor on power plants of this description may vary from 0.7 to 1.0, an average being 0.8, a regulating reservoir at the end of the pipe line becomes a necessity when using stored water.

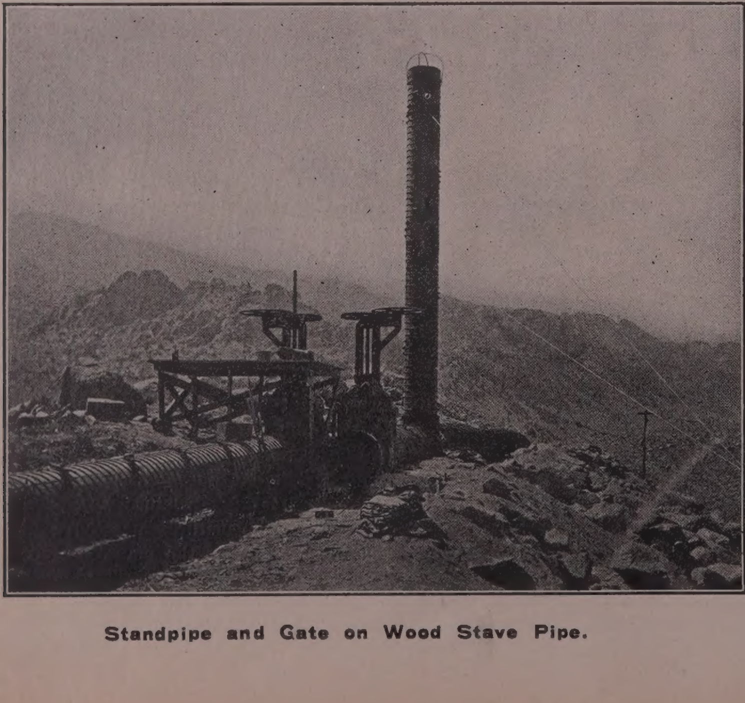
Water enters the pipe line through an intake chamber at one side of the dam. A screen is placed at the entrance to this chamber, made of ¼x1½-in. flat iron bars, the vertical bars being placed 2 in. apart and the horizontal bars 1 in. apart. Back of the screen are three timber gates operated vertically by rack and pinion. The wooden pipe enters the intake through the concrete wall, being built into it in place.

The pipe line is about 12,000 ft. long, consisting of 6,700 ft. of 42-in. wood-stave pipe, 2,150 ft. of 30-in. wood-stave pipe and 3,150 ft. of 24-in. steel pipe all diameters being inside measurements.

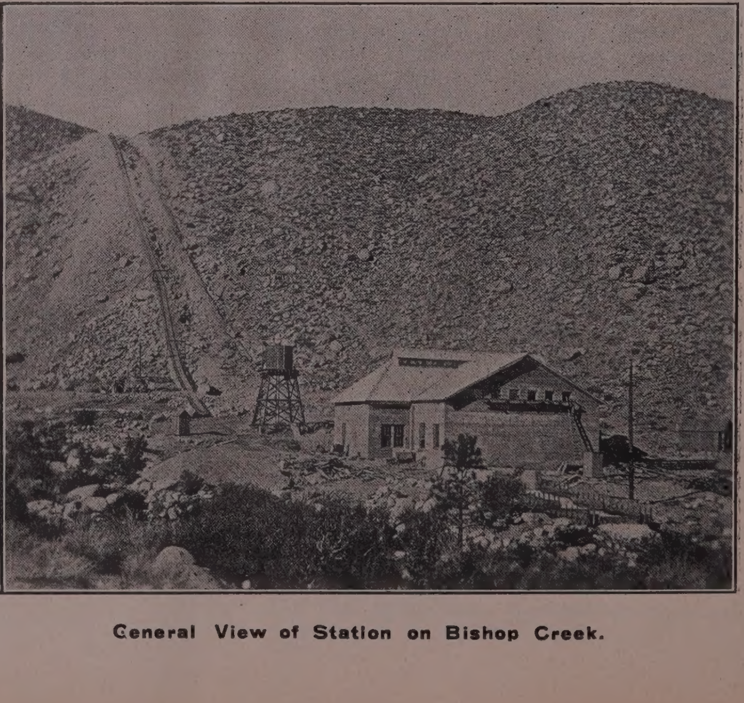
The 42-in. pipe lies on a nearly level grade, the static head at the lower end being about 30 ft. At this point are placed two 30-in. gate valves, one opening into the 30-in. pipe and the other provided for a future line. The 30-in. pipe descends the hill to a point that gives a static head of 265 ft. Here it joins the 24-in. steel pipe which descends a steep hill to the power house, the total static head being 1,068 ft. For about 500 ft. this steel pipe is laid on a slope at an angle of 38 deg. from the horizontal.

The 42-in. pipe is made up of twenty-five staves and the 30-in. pipe of nineteen staves, milled from a 2x6-in. piece. The lumber is red fir from Southern Oregon and the staves were milled there to the proper circle. The bands are of mild steel of circular section ½ in. in diameter with ends upset to ⅝ in. diameter. They were shipped straight and bent to form at the work. The lugs were of cast-iron of a form that allows the ends of the bands to pass each other and be tightened with nuts on each end. When the bands are tightened there is a slight bending of the rods, but this is not believed to be injurious. The ends of the staves were slotted and a 3/16x½-in. compressed paper dowel inserted. When wet this dowel swelled and was very effective in closing leaks.

Bands on the 42-in. pipe were spaced on 6-in.



Standpipe and Gate on Wood Stave Pipe.



General View of Station on Bishop Creek.

centers, although the pressure did not demand this close spacing. On the 30-in. pipe, which is subject to a considerable pressure, the writer used the pressure due to swelling of wood given by A. L. Adams, 100 lb. per square inch, but in addition to this an allowance was made for initial tension in the rods due to the stress necessary to bring the staves into form. The red fir is a very stiff wood, and by observation it was determined that it was necessary to use 2,100 lb. to bring the staves into position; this was calculated as being distributed along one lineal foot of pipe and distributed among whatever number of bands occurred in that length under different heads. Bands were spaced under these assumptions with a safety factor of four.

The question of initial tension on the rods is believed to be a vital one, as in the case of the stiff lumber used it required much cinching to make the staves come together. As the wood is hard, the bands crush into it but little under pressure and hence there is little relief to the stress. By tests it was determined that, with the wrenches used, an initial tension of 8,000 lb. per square inch could be easily obtained.

The wood pipe is laid directly on the ground, a few sills of culled material being placed at intervals. At points it was covered with earth as a protection from possible rocks rolling down the steep hillsides. The pipe was laid in easy curves, but in one case a curve of 100 ft. radius was made through nearly 90 deg. For nearly two months the daily amount laid averaged 110 ft.

The wood pipe is provided with two 6-in. and one 30-in. standpipes, the former being of casing and the latter of 30-in. wood pipe. In addition 6-in. air valves are supplied in such number that there is a 6-in. opening every 1,100 ft. On the steel pipe, three 6-in. air valves were placed at the upper end.

The material for the wood pipe was mostly hauled to the site on wagons, a minor portion being hauled up from the power house on the tramway used in laying the steel pipe.

The steel pipe is 24 in. inside diameter, of lap welded steel and was furnished by the Pelton Water Wheel Co., agents for the makers, a German firm. It is in three thicknesses, ½, ⅜ and ½ in. The sections are 30 ft. long and the ends are male and female, swelled and of cone shape, so that an angle may be made between sections. The maximum angle turned was 2 deg. 30 min. between two joints. The joints were connected by a single line of rivets, the holes being drilled in the field. The pipe is anchored at intervals by a strap clamped around the pipe and rods, with turnbuckles fastened to bed rock.

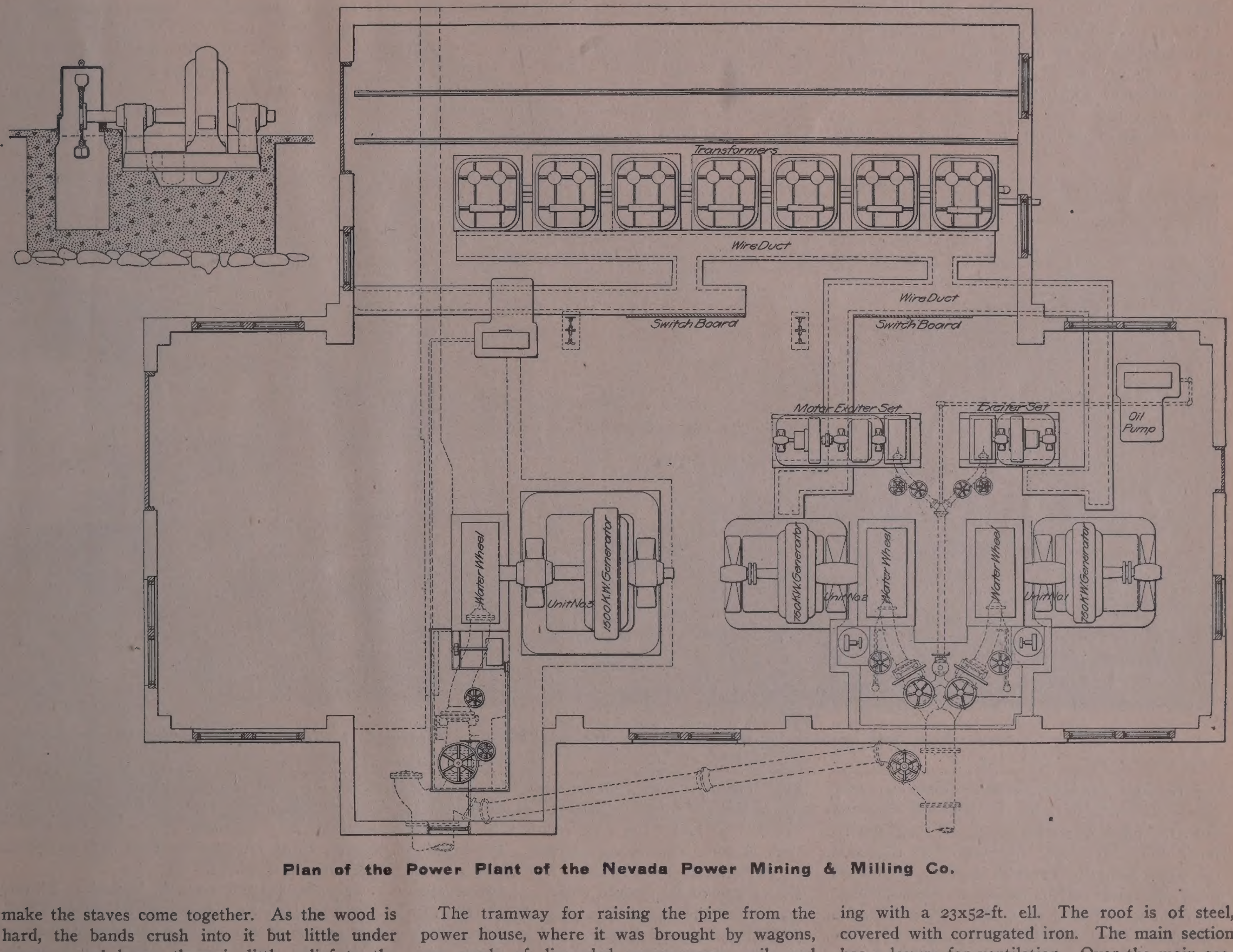
The tramway for raising the pipe from the power house, where it was brought by wagons, was made of discarded narrow-gauge rails and ties laid alongside the pipe trench. The pipe sections were hoisted to place on a single car about 8 ft. long fitted with cables to fasten the joint to the car. The hoisting rope was a single ⅝-in. steel cable, and the hoisting was done by an electric hoist made by the Hendrie & Bolthoff Mfg. & Supply Co., of Denver. This hoist was provided with a friction drum of large size and was very effective in handling the loads. The length of the tramway was about 3,300 ft., and as there were several horizontal curves in the line, the cable was held in place by vertical grooved rollers. Rollers were also provided on the straight sections and no difficulty was had with the car returning to the foot of the hill by gravity. Loads of 5,000 lb. were easily handled.

For drilling and riveting purposes, a compressor operated by an electric motor was provided near the power house and an air-pipe line run to the top of the hill. This line was made of about 500 ft. each of 2-in. and 1½-in. pipe, the remainder being 1-in. This air pipe was provided with connections at intervals, and air drills and air hammers were used on all the work. In laying the pipe, the holes in the female end were drilled in the yard. The section was then taken up on the tramway, laid in place and the male end drilled, after which it was riveted without being disturbed. This gave very tight joints. Progress on this work was slow in the rock trench near the power house, but for a distance of 2,500 ft. the pipe was laid at the rate of 3⅔ joints laid, drilled and riveted per day. The steel pipe has been entirely covered.

The power house is a 32x82-ft. concrete building with a 23x52-ft. ell. The roof is of steel, covered with corrugated iron. The main section has a louvre for ventilation. Over the main section is placed a 10-ton, hand-operated traveling crane running on rails supported by reinforced concrete girders of 16 ft. span. The crane was made by the Cyclops Iron Works, of San Francisco.

The building, together with the foundations of the machinery and the tail races, rests on a mass of large boulders, bed rock being unknown in the country.

The equipment of the station consists of two 750-kw., 60-cycle, 2,200-volt, three-phase alternating-current generators running at 450 r.p.m. They were made by the National Electric Co., of Milwaukee, the same firm supplying the exciters. In addition there is now being installed a 1,500-kw. generator running at 400 r.p.m., supplied by



Plan of the Power Plant of the Nevada Power Mining & Milling Co.

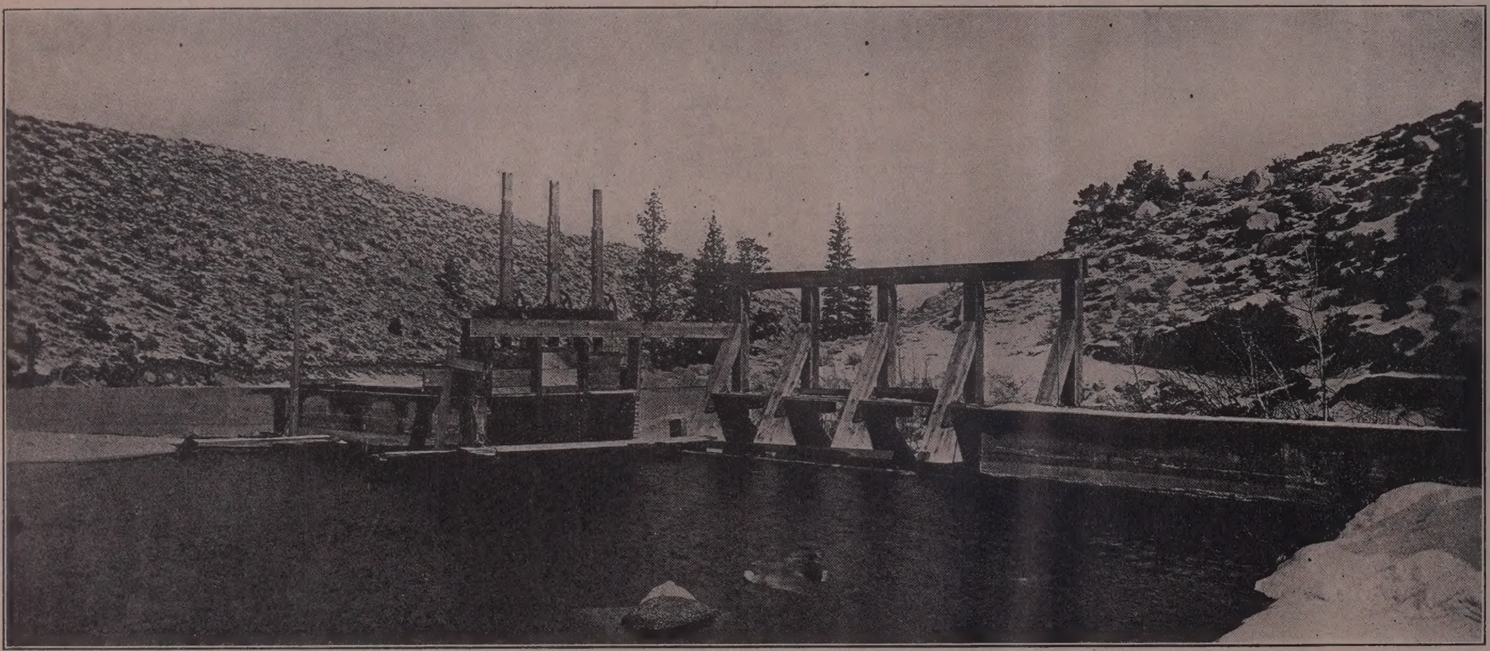
the Allis-Chalmers Co. This generator is shown in the sectional drawing and the location of it and the other machines is shown on the plan. There are two exciters of 60 kw. each, delivering current at 140 volts pressure. Both exciters are operated by waterwheels and in addition, one is provided with an induction motor.

The waterwheels for the entire plant were made by the Pelton Water Wheel Co., of San Francisco. The two 750-kw. machines have Sturgess governors and the 1,500-kw. machine has a type Q Lombard governor. Hand-control mechanism is provided for each wheel. Oil is supplied the governors by two oil pumps operated by water-wheels.

The generators are of the two-bearing type, the water-wheel overhanging the tail race.

From the generators the leads are laid in trenches to the switchboard and transformers. The switchboard is provided with Westinghouse instruments. The transformers, of which there is one spare, are 500-kw., oil-insulated and water-cooled apparatus, as made by the Stanley-G. I. Co. They are placed on pedestals and rest on iron rollers by which they can be removed to a car for repairs.

The power lines pass the wall of the building through windows of 28-oz. glass in 36-in. square panes, there being two panes to each window, the outer one with a 6-in. opening and the inner one with a 4-in. opening. The line from the power house to Tonopah is of stranded aluminum equivalent to No. 0 copper. From Tonopah Junction to Goldfield the line is No. 2 aluminum stranded. The insulators are four-part porcelain, 14 in. in diameter held on malleable iron pins. The triangle of the wires is equilateral, with 72-in. sides, and the spans are normally 310 ft. On parts of the line near railroads, cedar poles from Oregon were used and in the mountains native timber. The poles were equipped with a steel channel at the top, bent and fastened to the pole with bolts. The channel supports the top insulator.



Head Dam and Intake on Bishop Creek, Nevada Power, Mining & Milling Company.

The building of this line was done under extreme difficulties, due to heat and absence of water on the desert. The cost of watering a horse amounted to 85 cents per day, and this can be appreciated when it is stated that if a four-horse team started on a day's haul, a similar team went along with the necessary water for the two.

A telephone line was built parallel to the power line, but on separate poles, and the wisdom of this has been shown this winter. The line is also practically free from the induction usually found where the telephone line is placed on the power line poles.

A switch station was built at Tonopah Junction and sub-station at Tonopah and Goldfield. They are of stone and each contains three oil-insulated, air-cooled Stanley transformers of 300 kw. each. Current is reduced to a pressure of 6,600 volts for local distribution.

The line has been operated at a line pressure of 30,000 volts, but when the demand arises for more power, it will be operated at 50,000 volts by connecting the transformers in star.

The officers of the company are: F. J. Campbell, president; G. G. S. Wood, secretary, and C. M. Hobbs, general manager. The main office is at Denver, but the management of the construction was in the hands of Mr. C. M. Hobbs, at Tonopah and Bishop. Mr. C. O. Poole was consulting engineer on the entire installation of the first two units. R. M. Jones, in conjunction with Mr. Poole, designed and located the plant. The head dam, the pipe trench and a part of the wooden pipe were built under Mr. Jones' supervision. The construction of the remainder of the pipe, together with the building of the power house and the installation of the machinery, was carried out under the supervision of the writer, with Mason Galloway as assistant. The installation of the 1500-kw. generator and wheel is under the charge of the writer. The line construction was under the supervision of L. B. Curtis, with J. B. Balcomb and Charles G. Patrick as assistants. The operation of the power house is in charge of J. W. Todd, as superintendent.

Active work was commenced early in March, 1905, and current was turned on to the line on Sept. 17, since which time the plant has been in successful operation.

THE DANGEROUS CHARACTER OF THE GASES given off by linseed oilcake is exemplified by the recent explosion in the hold of a ship in Liverpool harbor containing a cargo of this material, which was attended with serious loss of life. It is evident that greater care must be exercised in the shipment of such materials, involving thorough ventilation of spaces used for storing them, particularly in holds of vessels where temperatures are liable to range above the average.

A Model New Abbattoir in New York City.

In the recent report of the government commission appointed to investigate packing house and abattoir conditions in this country, a model abattoir plant in New York City was mentioned as exemplifying the conditions which, if applied to the packing establishments throughout the country would revolutionize the industry. The model abattoir in New York referred to is the new plant of the New York Butchers' Dressed Meat Co. This company was incorporated in 1902 with $1,500,000 capital, to supply local butchers in New York City and vicinity with home-dressed meat, slaughtered with regard to high standards of sanitation and cleanliness. It has recently completed, near the North River front in New York, a model abattoir, with a modern mechanical and refrigerating equipment and apparatus for the recovery of the by-products of animal slaughtering. Owing to the rigid requirements of the New York City Board of Health, this abattoir also includes special provisions to secure cleanliness in all departments and to prevent communication of offensive odors from the plant to the adjoining neighborhood. Most careful study was made of all requirements for rapid production, combined with sanitary perfection, and the result of the installation has been very satisfactory, the operation of the abattoir being attended, in fact, with exceptional economies throughout.

The new abattoir plant is located at Eleventh Ave. and 39th St., about 900 ft. distant from a pier on the North River front, where cattle are received by water shipment and also from convenient railroad connections. The plant consists of a main abattoir building, 98 x 125 ft. in size and five stories high, on the northerly side of 39th St., adjoining which to the rear is a 47x98-ft. building devoted to fat rendering and fertilizer processes, and beyond this structure, a 78x98-ft. power house building. On the south side of 39th St., at the corner of the block, is a single-story cooler, or storage building, 100 ft. square, and a 25x94-ft., three-story freezing building, both of which are used for salesrooms. Pipe connections for the refrigerating, hot and cold water and steam distribution systems, are made from the power house to these buildings through a pipe conduit beneath the street. The company has also obtained adjoining property through to

40th St. on the north in order to provide for probable future extensions.

A circulation water supply for condensing purposes at the power house is obtained through a 16-in. salt water suction pipe extended beneath the street to the river front and 500 ft. out into the river. The dockage privileges consist of a 20-year lease of a 150-ft. pier at the foot of 39th St., with the privilege of temporary closures of 39th St., for driving of cattle to the abattoir building. By these provisions, cattle may be lightered by boat from any of the trunk line railway terminals on the New Jersey side of the Hudson River. A spur track has been extended from the freight division of the New York Central lines in Eleventh Ave. into 39th St., and along one side of the abattoir building so that direct rail shipments may also be received.

The design and arrangement, as well as the mechanical equipment, of the abattoir involve a considerable departure from the usual slaughter house practice in that the stock pens, the killing house and meat dressing department, cold storage rooms and salesrooms have all been incorporated in a single building, which has been extended vertically instead of horizontally. This arrangement is due primarily to the high cost of real estate on which the plant is located. The establishment of a plant with a capacity of butchering 2,800 cattle per day, or 16,800 per week of six days, together with ample cattle pen storage and refrigerator storage for the dressed meat, has been secured, however, on a ground plan of 98 x 125 ft.; an installation of similar capacity designed along the lines of the usual packing house practice, would require a ground space for stock pens and buildings of at least more than 250,000 sq. ft.

Exterior of the New Abattoir in New York City.

The Abattoir Building.—The main abattoir building is a steel and brick structure, having a frontage of 98 ft. on Eleventh Ave. and a length of 113 ft. on 39th St., with a 12-ft. space between this building and the fat-rendering house for a cattle runway. The abattoir building is a five-story, basement and mezzanine structure, with an exterior treatment in buff brick and limestone. The building has a steel-cage frame with cinder concrete floors and partitions, all steelwork being thoroughly protected by concrete. Owing to the extensive installation of beef coolers in the basement, first, second, third and fourth floors, extraordinary provisions have been made for heat insulation; the floors, walls and ceilings of all refrigerating rooms are thoroughly enclosed with granulated cork pressed into sheets, and so laid in double layers as to break joints and avoid all possible connection with the outside air. The windows in these rooms have quadruple sash; and heavy tight-closing insulated doors are used for all other openings in its walls. The side walls were coated with moisture-proof magnesia plaster, before the insulation was put in place. The floors are of wood, laid upon asphalt in herringbone pattern.

An important feature of the building construction is to be noted in the installation of rat stops on all floors to prevent rats and mice gaining admission. This is specially important in the coolers, as it is well known from usual abattoir practice that rats prove to be one of the most destructive factors in the storage of meats, both on account of the amount of gnawing the meat they may do, and also because of the destruction of the tightness of the insulation of the cooling rooms by gnawing holes through the floors. For this purpose, woven wire netting has been embedded in the concrete of the floors at the edges of all rooms and turned up into the side wall or partition construction, which eliminates the possibility of the rodents gaining admission to any room by gnawing through. As rats always work near the floor in gnawing holes, it was not considered necessary to carry the netting up higher than 2 or 3 ft. from the floor, owing to the absence of wooden construction in the building. A sanitary advantage of importance in providing for the exclusion of rodents is the freedom from infection possible from this source which is gained, since rats are known to be effective carriers of disease bacteria.

The cattle sheds are arranged on the roof of the abattoir building 100 ft. above the sidewalk level, the killing and meat-dressing departments upon the fifth floor and a mezzanine above, while the beef chilling and cold storage rooms are distributed upon the lower floors, with salesrooms in the first story and basement. The result of this arrangement is a continuous downward movement of the beef from the time the cattle leave the pens on the roof until the beef is delivered in quarters from the salesrooms. The main floor is 21 in. above sidewalk level and has a clear height of 17 ft. 3 in. The basement has a clear height of 12 ft. 3 in., the second, third and fourth stories 13 ft. 9 in., while the fifth story has a clear height of 32 ft., and is in one large room, with a mezzanine gallery, 23 ft. wide on the two sides of this room, which gallery is 17 ft. 9 in. above the floor. The open space above the center of the killing floor extends to the roof in which a number of 10-x-18-ft. pent-house openings are located to ventilate the fifth story and the mezzanine floor. The roof is surrounded with high parapet walls and contains sheds for the protection and feeding of the cattle as received.

An important factor in the sanitation of the building has been the interior finish, which has been selected with special regard to imperviousness and freedom from contamination by the processes involved in the building. A liberal use of white enameled brick has been made for side walls in all parts of the building, not so much for appearance as to secure a finish impervious to moisture. Both the side walls and floors of the beef coolers have been thoroughly waterproofed so that the beef is stored under the most favorable conditions of dry surroundings. A wooden floor covering over the asphalt was selected for these coolers as the cleanest and most durable material. In the killing room, the side walls are of white enameled brick throughout and the floors are finished with a waterproofed blue stone which is very durable, yet not dangerously slippery when wet. This floor is graded to numerous drainage gutters to permit of frequent and thorough washings by the hose, the entire floor and all apparatus being given a very thorough washing daily after the butchering is completed.

Operation.—Cattle are delivered to the stock sheds on the roof by a series of reverse inclined plane runways arranged in the 12-ft. space between the abattoir and the fat-rendering house, up which runway they are driven from the street. The runway is a passage 6 ft. in width with steel-plate walls, 6 ft. high, on either side, and has steel flooring with transverse steel cleats placed about 6 in. apart to provide a good foothold. It is built in four sections from the street level up to the level of the fifth floor, where a level gallery of similar construction extending the width of the building is placed; from this gallery a two-section runway is carried up first to the opening at the fifth floor mazzanine, reversing from there up to the roof level. The various sections are inclined at slopes of approximately 1:5, so that the cattle can mount them easily. There is also provided over the entrance to the runway from the street, a hoist by means of which an animal that has been injured slightly in transportation and is unable to mount the runway, may be lifted in a sling up to the killing-floor level for immediate butchering.

The roof storage consists of nine large cattle pens separated by pipe railing partitions and all well covered by roofs of galvanized iron construction, which have an aggregate capacity for 17 carloads of cattle. The entire space is surrounded by an alleyway, from 6 to 9 ft. in width, with an alley across the middle between rows of pens; the alleys are not covered and are utilized for the drainage gutters, in the roof surface, the pen floors being pitched sharply toward them. Each pen has a watering trough for the cattle and feeding racks, and provisions have been made for enclosing the pens for winter weather. Additional protection in winter is provided by the tank house, fan houses, elevator machine room and skylights upon the north side of the roof which rise to sufficient height as to act as wind breaks in cold weather. The entire roof is paved with vitrified brick upon a concrete flooring to permit of washing down with a hose in cleaning.

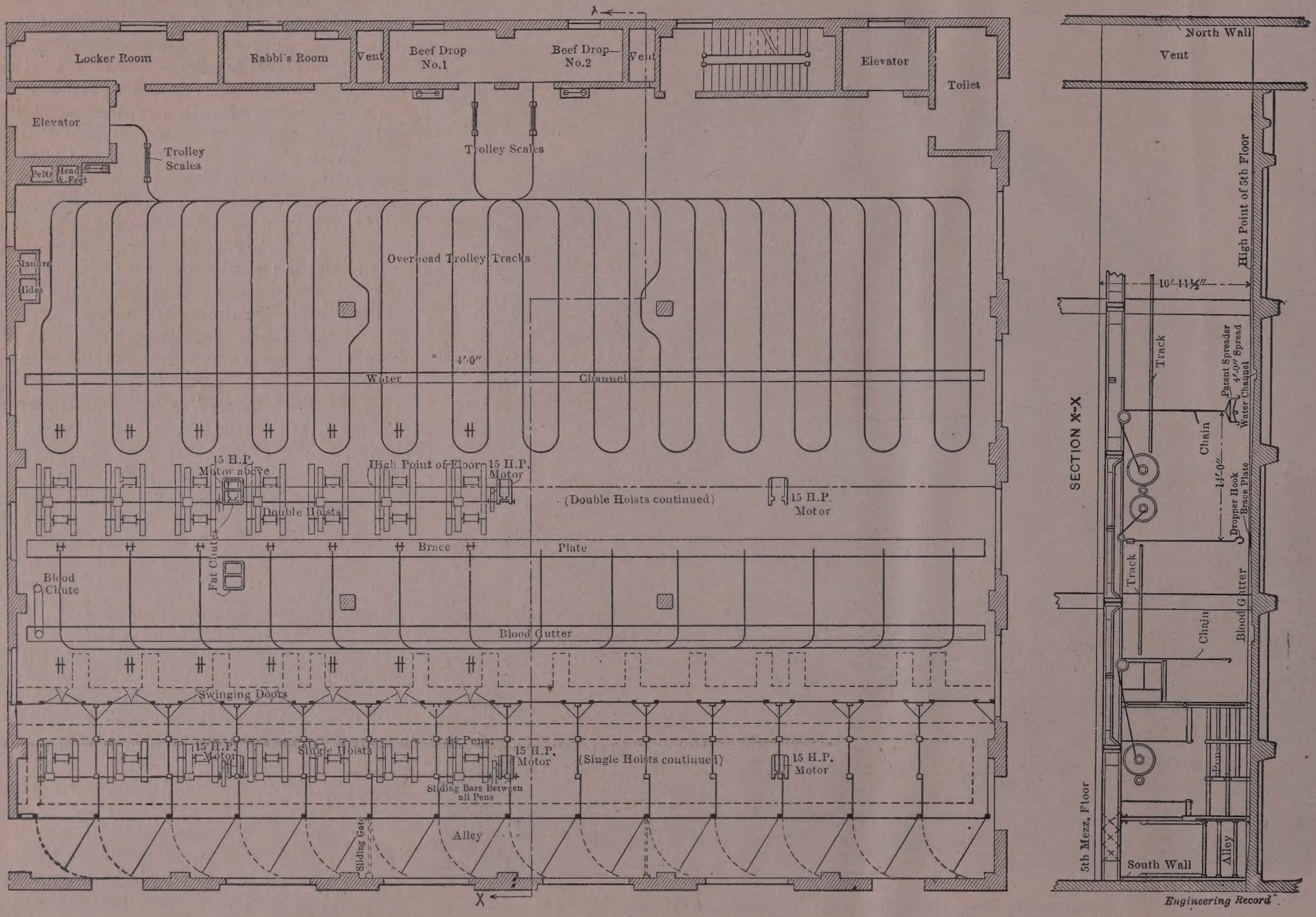
The cattle are delivered from the roof pens to the killing floor by driving back down the runway to the mezzanine entrance, or to the level gallery outside the fifth floor, as required, all sheep and calves being butchered in the mezzanine gallery, and cattle on the main fifth floor. Alleyways lead from the runway outside to killing pens on both the main and the mezzanine floors, the latter being arranged throughout on the open court side of the gallery.

The pens on the main killing floor are arranged on the south side, with a 7-ft. alleyway between them and the wall, and are fourteen in number, each 7½ x 13 ft. in size.

The killing space proper consists of an area, 18 ft. wide in front of the pens, with a blood gutter in the floor 8 ft. from the pens. The operation of killing in this abattoir is practiced according to the kosher method of the Mosaic law of the Hebrews, and consists in lifting the cattle by the hind legs with chain hoist until only the head touches the floor, and then cutting the throat so that the head is nearly severed. The carcass is thence quickly hoisted up and held while profuse bleeding takes place, the hoisting gear used consisting of a drum with a special friction clutch and brake, with both hoisting and holding operations controlled from a distance to the rear. This entire section of the floor is pitched sharply toward a blood gutter. This gutter consists of a cast-iron trough, 18 in. wide by 6 in. deep, sunk flush in the bluestone floor and is connected with a pipe leading to the fat-rendering house where the blood is converted by the Powter process into fertilizer.

The central portion of the floor beyond the row of columns is devoted to the work of skinning and dressing, the carcasses being dropped on the floor beyond the gutter after the bleeding is completed. On this floor the carcasses are rapidly skinned, the feet and heads removed and preparation made for the final dressing. A number of chutes for the delivery of heads, feet, hides, pelts and manure to the lower floors for rendering or removal, are placed along one side of this portion of the floor. In dressing the carcasses, they are cut open, spread and then lifted by other hoists installed over this section, which hoists are fitted with special spreader hooks for assisting in separating the halves of the beef in the process of the lifting. When the dressing is practically completed each carcass is hoisted further and each half hooked upon the trolleys of a pair of overhead runways and then finally cut into halves, and the dressing and trimming completed. The overhead runways, which span each of the latter hoists in pairs, lead back to the inspection floor and the weighing scales. The carcasses are here subjected to double inspection, having to pass the careful scrutiny of the Hebrew rabbis in addition to that of the U. S. Government Inspectors.

Both overhead runways and chutes serve for the removal of materials from the killing floor, all of the dressed halves being run on the overhead trolleys from the weighing scales to beef drops in the corridors outside and thence lowered to the chilling rooms and later to the coolers for storage. The equipment of chutes includes three leading to the ground level, one to the basement and two to the fat picking section of the fourth floor below. Those leading to the ground floor deliver into bins in the areaway beneath the cattle runway, one having openings on the fifth floor, mezzanine gallery and roof, respectively, for the removal of manure, while the other two start from the killing floor, one delivering heads and feet to a bin and the other is used for pelts; the fourth delivers hides to the basement of the fat-rendering house. The overhead track system is interchangeable throughout the building, so the trolleys carrying halves of beef may be transferred from one floor to another and thus operate over tracks in any of the coolers or salesrooms. The track installed upon all floors consists of 2½x½-in. steel bars mount-

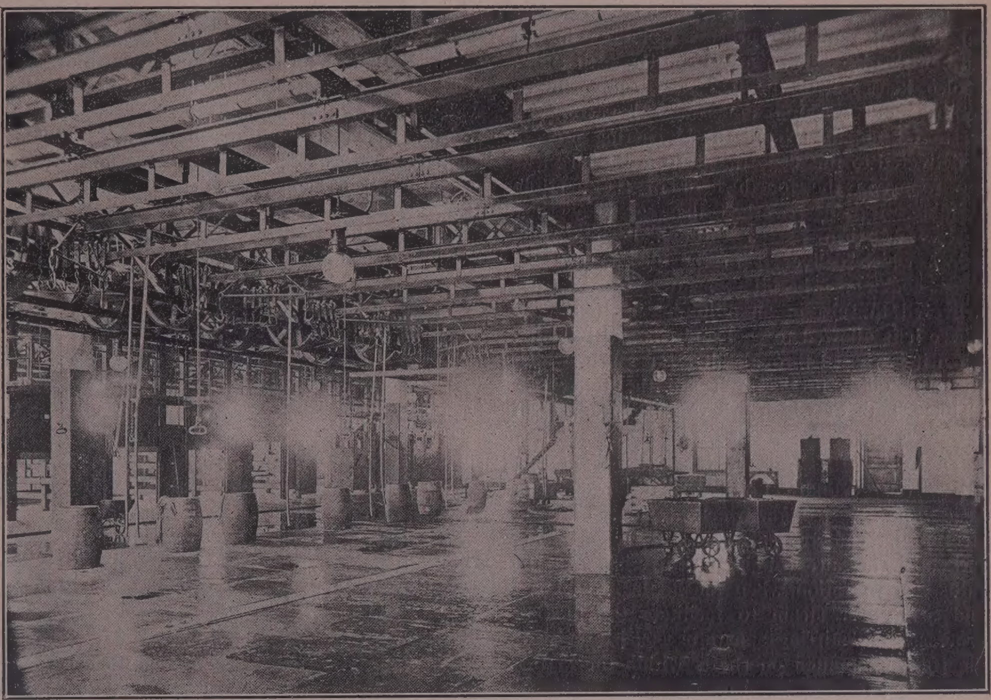


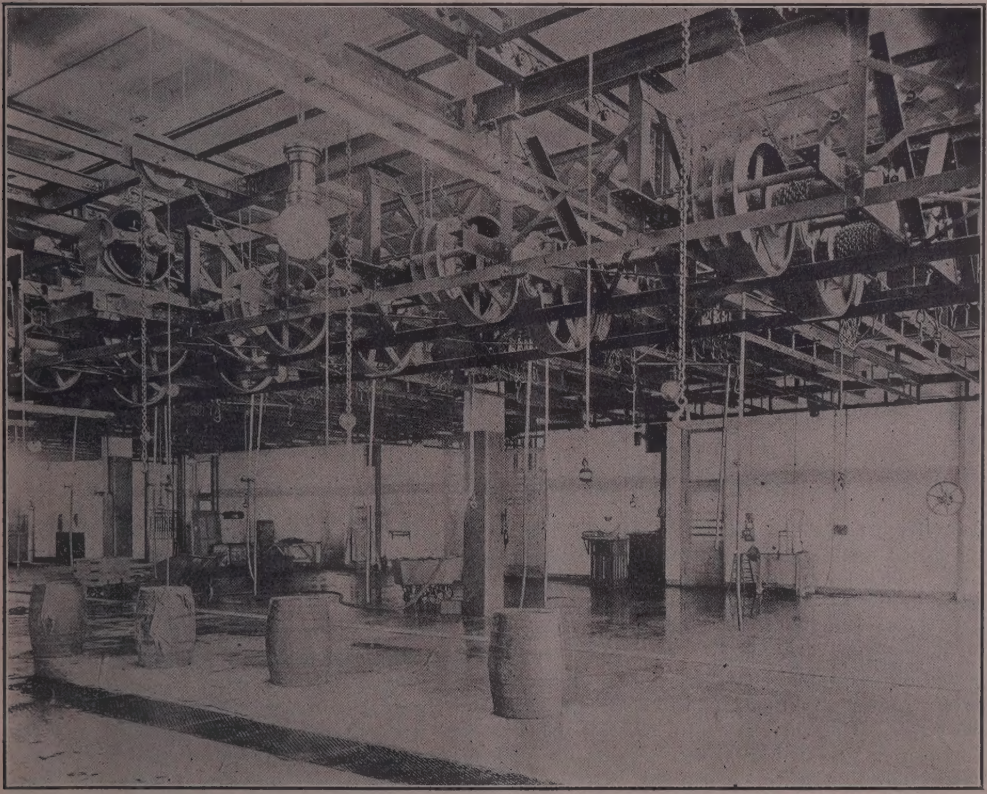
Arrangement of Beef Hoists and Trolley Trackage on the Killing Floor.

ed edge wise, except above the killing floor, where 3x⅝-in. bars are used on account of the more severe duty to be imposed upon them there. The track bars have rounded upper surfaces to conform with the rollers of the Moyer standard trolleys used, and are suspended from floor beams above, or from special track beams by forged hanger straps, spaced from 18 to 30 in. apart, according to the location and the duty imposed. A form of Duncan switch operated by detachable hook rods from the floor below is used in the trackage at all switching points. Fairbanks scales of 4,000 lb. capacity are used for the tramrail scales for weighing beef on the killing floor, and there are also similar scales on the mezzanine killing floor and also in the basement and first floor salesrooms. This equipment was installed by the William R. Perrin Co., Chicago, Ill.

Two electrically operated freight elevators carrying overhead trolley trackage connections for handling beef directly on the trolleys without removal have been installed to convey carcasses from the killing floor to the refrigerating rooms below and thence to the salesrooms. These machines operate in shafts in the corridor space on the north side of the building, from the fifth mezzanine to the basement, and are capable of hoisting 4,000 lb. each at a rate of 100 ft. per minute. These elevator machines were installed by the A. B. See Electric Elevator Co. They are located in roof houses above the shafts and are of the drum type connecting directly to the elevator mechanism. The cars are counterweighted and are equipped with automatic top and bottom stops and safety apparatus to prevent dropping.

The friction hoists used in handling carcasses of animals on the killing floor, embody a construction which permits them to be controlled for lifting, lowering and braking by a single rope. These hoists were made by the Weir & Craig Mfg. Co., of Chicago, Ill. There are 14 of them of a single type installed over the killing floor for lifting animals during the killing and bleeding, and 14 more of a double type over the dressing floor, which are equipped with drums on one side for hauling the carcasses from the bleeding position over and dropping them in the middle of the dressing section preparatory to the removal of the hide, etc. The further sides of these hoists are then brought into use in lifting the carcass by means of the special spreader hooks during the final dressing and halving operations. The relative locations over the killing floor are shown in an accompanying cross-section of the fifth floor with equipment.


General View of the Killing Floor on the Fifth Story of the Building.


Arrangement of Beef Hoists and Control Ropes above the Killing Floor.

These hoists consist of a simple arrangement of winding drums with large band wheels which are driven by small raw-hide pinions on a line shaft revolving at constant speed, and braked by friction shoes opposite the driving pinions. The friction pinions and the brake shoes are stationary, the method of control involving the movement of the friction band wheel forward and back between the driving pinion and the braking shoe, sufficient clearance being left between them to permit of an intermediate position of the band wheel in which it touches neither. This clearance is adjusted at about ½ in., the construction of the apparatus being such that the bearing at the band-wheel end of the drum shaft has a longitudinal play between guides and is moved back and forth therein by a bell-crack lever extended and heavily counterweighted at one end. The ratio of this lever is such as to require a considerable movement of the counterweighted end to move the band wheel appreciably, and its operation is thus made simple, yet positive. To hoist the load, the counterweighted end of the lever is raised, which forces the band wheel against the driving pinion and causes it to revolve, which action is utilized for the hoisting. For stopping or checking the drum in lowering the load the counterweighted lever is merely released whence it at once drops and forces the band wheel backward against the brake shoe. For lowering an intermediate position of the lever may be obtained in which the band wheel touches neither the driving pinion nor the brake shoe when it will release and lower the load rapidly, or it may be lowered gradually by only partiallly releasing from the friction shoe. The counterweighted lever is lifted by means of a rope leading over pulleys to a convenient position for the operator and is very easily manipulated. In operating, the lever is lifted quickly to allow no appreciable interval in passing from the braking to hoisting position, so that the load is not permitted to drop back at all, whereas in any case, when the rope is released, the brake is applied and the drum stops. The line of single hoists over the killing floor and also the line of double hoists over the center of the room are operated by three sections of shafting carrying the friction pinions, each of which is driven by a 15-h.-p. General Electric motor.

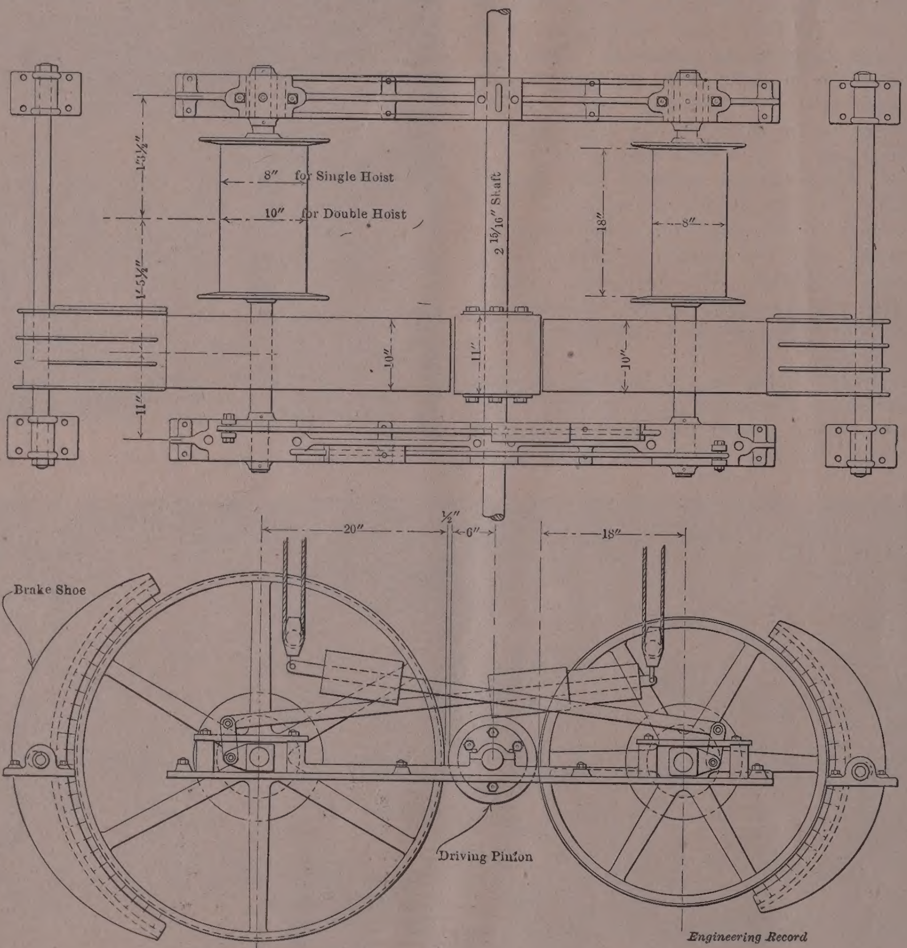
Fat-Rendering Plant.—The rendering of waste fat and the reclaiming of by-products are accomplished in the 47x98-ft. brick building at the rear of the abattoir and also on the two upper floors of the power house building adjoining, which has been utilized for this purpose. The fat-rendering building is of mill construction, five stories and basement in height, and contains upon the upper floors the equipment for the rendering of fat, upon the lower floors the Powter system apparatus, and in the basement provisions for the salting and storage of hides, which are dropped to this level direct through a steel chute leading from the killing floor of the abattoir building. The floors of the building have been thoroughly waterproofed so they may be washed with a stream from a hose.

The equipment in the fourth and fifth stories for the fat rendering process embraces in the former 18 oleo kettles, and upon the fifth story, 9 oleo kettles with the necessary equipment of cooling and washing tanks and hashers. All waste fat obtained from the butchering process is delivered to this department from the fat picking room on the fourth floor of the abattoir building. It is first washed, then sorted, washed again, and then passed through hashing machines which deliver it to the oleo kettles for steam cooking. The oil thus produced is thence delivered to tubs in an adjoining heated room where it is allowed to cool and congeal partially, when it is passed through filter presses by which the oleo oil is pressed out and the tallow reclaimed, both of which are valuable products of the process.

The oleo kettles for the fat-rendering process are vertical cylindrical tanks, 4 ft. in diameter inside and 4½ ft. high, which are built of ¼-in. steel plate, and are surrounded by 2-in. steam jackets. They are equipped with stirring apparatus, for operation when the kettles are closed and are under steam to facilitate the melting process. The stirring apparatus consists of paddle frames mounted on shafts within the kettles and driven through bevel gearing from overhead shafting, each frame being driven from the vertical shaft through a special form of clutch, operative only when the agitator is inserted into the kettle. The agitators of the 27 kettles are driven in three groups each by a 15-h.-p. General Electric back-geared motor. The draw-off connections for the kettles consist of 2-in. pipe connections extended into the kettles with a movable pipe orifice and double elbows, so that the oil can be drawn from the surface and the outlet pipe opening be swung down as the surface lowers.

Additional tankage equipment for this portion of the installation includes an oil tank on the first floor which is used for storage of the oil released at the filter press until barreled for shipment, a jacketed scrap tank for further treatment of the meat scraps from the oleo kettles and a number of scale and cooling tanks. The washing tanks on the fourth and fifth floors consist of open wooden tanks 10 ft. long by 6 ft. wide and 3½ ft. deep, with numerous water spray jets in which the sorted fat is floated and sprayed for thorough cleansing before melting. These tanks have ammonia expansion pipes for partial cooling of the water, which is recirculated through the water sprays by small centrifugal pumps driven by electric motors. The tanks and kettles were installed by Theo. Smith & Son Co., of Jersey City, N. J.

The Powter system equipment for the recovery of by-products from waste fats, offal and blood is installed upon the second and third floors of this building and consists of two combination digester and separator units and one blood dryer. This apparatus provides for the particular digesting operations in closed vessels and drying under vacuum, by means of which the operations are conducted absolutely without communication of odors to the outside atmosphere, rendering the plant and its process inoffensive to the adjoining neighborhood. Each of these units consists of two vertical tanks in which the material is charged and cooked or otherwise treated, and below them horizontal dryer tanks with motor-driven stirring, or agitating, apparatus. The purpose of the blood dryer unit is to receive the blood from the killing floor and to permit its evaporation and subsequent drying, for the production of fertilizer material. The blood is discharged alternately into the two vertical receiving tanks of this unit and is being cooked in one, while the other is being emptied to the dryer, the provision of two receiving tanks permitting of continuous operation. The digester and separator units operate similarly for the cooking and disintegration of all beef wastes from other portions of the plant, trying out the fat, the oil from which is drawn off and saved, leaving a plastic residue which passes through the dryer and is similarly prepared for fertilizer material.

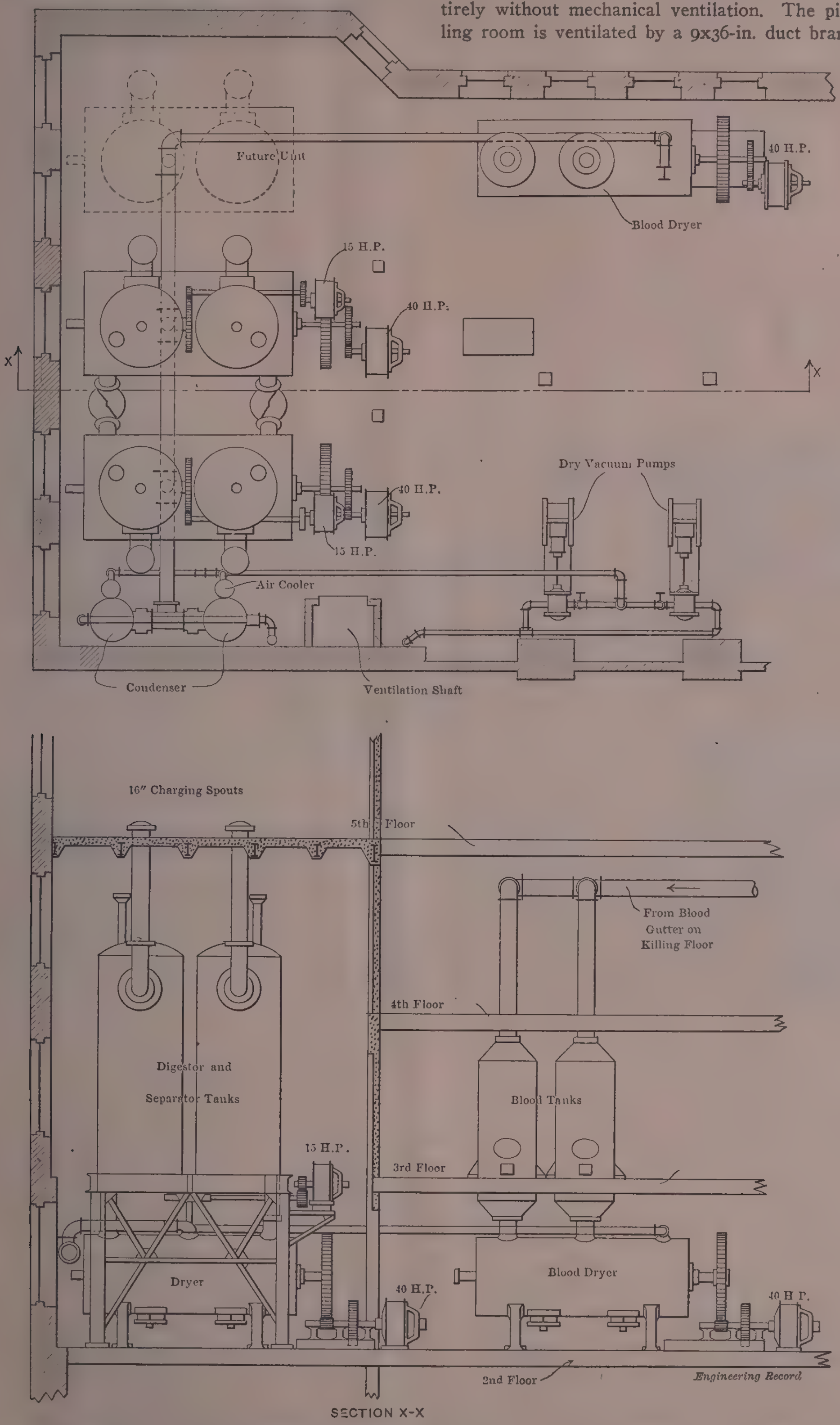


Details of the Beef Hoists used on the Killing Floor.

The blood dryer apparatus consists of two vertical steel-plate receiving tanks, each 4 ft. in diameter and 13 ft. high. These tanks are mounted on a structural-steel framework on the third floor level and have direct connections from the blood gutter drain by 12-in. pipes from above. The lower ends of the tanks project through the third floor and connect to a horizontal steel dryer tank, 5 ft. in diameter by 15 ft. long, on the second floor. This tank is supported on cast-iron standards and is fitted with stirrer blades on a longitudinal shaft through the center. This shaft is driven through reduction gearing by a 40-h.-p. General Electric motor geared down to drive the stirring shaft at 15 r.p.m. The digester units are of similar construction, but have larger tanks, the vertical tanks being 6 ft. in diameter by 16½ ft. high. They are mounted in an open space at the rear of the building extending from the second to the fifth floor, and are fitted with charging spouts of 16-in. pipe, which are carried up through the fifth floor. The latter has a passageway connecting across to the fourth floor fat-picking room of the abattoir building for convenience in delivering offal and waste fat to the digesters. These tanks are also fitted with stirrer blades for the agitation of the material during digestion, both of the stirrers being driven at 15 r.p.m. by an individual 15-h.-p. motor. The two tanks of each unit are connected at the bottom with a horizontal dryer having a mechanical agitator. This dryer is of similar construction and capacity and is operated similarly to that of the blood dryer unit.

The dryers of all units are operated under vacuum to facilitate the drying process. The vacuum equipment consists of two No. 4 Smith-Vaile counter-current condensers arranged in one corner of the apparatus room, with a 12-in. vacuum line leading to the various equipments and 6-in. branches to each condenser. Water is supplied to the condensers by a 5-in. water line which passes first through an air cooler and thence to the jets, the air cooler serving to cool the entrained air which is drawn from the injection chambers by an equipment of two 10x16x10-in. rotary dry vacuum pumps. The tail pipe from each condenser is an 8-in. line which drops a distance of 35 ft. from the condensing chamber outlet to a hot well in the basement from which overflow connections are made to the sewer. This entire equipment was installed by the Platt Iron Works, Dayton, Ohio.

Ventilation.—A novel form of ventilation has been made use of in the fat-rendering building for the removal of odors given off from the fertilizer material on the lower floors and from the rendering kettles upon the upper floors. It embraces carrying the gases downward through a system of ductwork for delivery to the boiler furnaces, through which they are passed for deodorization. The vent connections to the various sections of the fat-rendering building consist of register openings at each floor into a 36x52-in. vent riser shaft. This shaft is closed at the top and has a connection in the basement, 48 in. square in cross-section, through the power-house basement, to an air tunnel beneath the boiler furnace ash pits, by which gases are delivered to any of the furnaces. The strong draft of the power plant chimney, 175 ft. in height, creates a rapid flow through the duct which is capable of changing the air in the entire building approximately three times an hour, and correspondingly more rapid, if arranged to draw from certain floors only. The intensity of the draft is dependent upon the opening of the ash pit doors, which tend to by-pass the duct suction. This system has proven very effective in operation, withdrawing the odor from the fertilizer material so rapidly and completely that there is no indication given on the outside as to the purpose of the building, even though the outside windows be left open.



Arrangement of the Powter System Apparatus for the Disposal of Waste.

Extensive provisions have been made for the mechanical ventilation of the abattoir building, but after continuous operation for several months through both winter and summer weather, it has been found that such ventilation is unnecessary, except in the pickling room in the basement. The natural ventilation of the building is such that all parts are made perfectly comfortable entirely without mechanical ventilation. The pickling room is ventilated by a 9x36-in. duct branch from the fat house system, which connects to the 48x48-in. horizontal duct in the basement. The nature of the work in the fat picking room on the fourth floor does not, as was expected, require mechanical ventilation, being connected by a number of openings with the killing floor above which has unusual provisions for ventilation. This room has six 10x17½-ft. pent house ventilators in the roof with louvred sides offering free escape for the steam and foul air incident to the operations in this department. As a result the fog and vapor usually present in killing rooms of abattoirs have here never been experienced.

The buildings of the abattoir plant were designed by Horgan & Slattery, architects, No. 1 Madison Ave., New York, who also acted as engineers in the design of the mechanical equipment in consultation with Pattison Bros. The designs of both the abattoir and its equipment are the result of the very careful and extended study of abattoir conditions by Mr. Arthur J. Horgan, who made special examinations of all abattoirs of importance in this country, and Mr. Arturo Rodriguez, chief engineer, and Mr. E. T. Macdonald, chief assistant architect for Horgan & Slattery. The refrigerating system and also the interesting power plant will be referred to in subsequent articles.

The Design of Hydro-Electric Installations as a Whole.

Abstract of a paper read before the National Electric Light Association by Mr. E. F. Cassel.

Prior to the development and perfection of electrical transmission the utility of water-power was confined to work to which it might be applied in its immediate vicinity. The only means of transmission were either by transmitting the water itself, converting the power into compressed air, or mechanical transmission by means of wire cables. Under these conditions the usefulness of water-power was as restricted as the means for utilizing it. The use of hydraulic turbines was practically confined to the driving of small individual installations. Wheels of 200 to 300 h.-p. were considered large. The amount of water available for the power required was usually unlimited and efficiency was of little consequence. Connection between the turbine and driven shaft was by means of belt, rope drive or gearing, making one design available for many different speeds and a few designs sufficient for all speeds. Regulation was sometimes attempted and the results as often ignored.

The development and perfection of electrical apparatus marks a new departure in hydraulic power requirements, the most important development being long-distance transmission. Every mile added to the practicable distance of transmission of electrical energy either increases the market for an already developed water-power or brings into the market one heretofore undeveloped. Instead of running a factory or factories in its immediate vicinity the waterfall is now called upon to supply power for towns and cities within a radius of many miles. From all quarters comes the demand for efficiency; 3,000-h.-p., 4,000-h.-p., 10,000-h.-p. wheels are required and specified as glibly as the 200-h.-p. and 300-h.-p. wheels of earlier days. Efficiency demands direct connection of the turbine to the generator, a point of more than passing importance in that one design is no longer available for a large number of speeds, and the turbine as a consequence becomes only a part of a complete machine, all parts of which must be considered as a whole in order to secure the results demanded by modern practice. Step by step the cry for efficiency has forced improvement in hydraulic design and manufacture, until to-day the principal opening left for improvement would seem to be in the design and manufacture of hydraulic power installations as a whole.

The marvelous electrical development of the past few years has been accomplished by the electrical engineer and principally in conjunction with the steam engine as prime mover. This fact has in itself been a serious drawback in the development of proper designs for hydro-electric installations, as it has led the electrical engineer to call often upon the hydraulic engineer to fulfil requirements which were, if not impossible, to say the least, undesirable. Experience is slowly remedying this trouble and impossible specifications are not as usual as formerly, but there is still room for improvement. Consulting engineers now universally recognize the necessity of conforming in general design to the requirements of hydraulic practice, but, unfortunately, many are still prone to accept the results achieved by the hydraulic turbine in small units, and as an individual machine, as sufficient data for their study in the design of a modern hydro-electric installation.

In steam engine practice the boiler pressure may be and often is specified. Were the water pressure under which hydraulic turbines may be designed confined within as close limits as the steam pressures under which steam engines are designed, the difficulties of hydraulic design would be largely removed. This is only one of the problems to be met. The maintaining of efficiencies under widely varying pressures in the same plant, the maintaining of uniform speed under widely varying volumes of water at different times of the year without serious loss in efficiency, the maintaining of close regulation with inelastic water instead of elastic steam, and other equally difficult points, should plainly point out the necessity of giving the design of the hydraulic turbine different consideration and treatment from that of the steam engine when used in connection with electric generating plants if it be desired that these plants shall produce the best possible results.

In a hydraulic installation the water pressure is a fixed physical condition. The minimum amount of water available is also a physical condition, which can not be varied at the will of the designer. These essentials being fixed factors in the problem, it follows that to secure the best efficiency and produce the most satisfactory results equipment must be furnished best suited to these fixed conditions. Too often this self-evident fact is either ignored or not treated with sufficient importance. Specification after specification is received by the manufacturer with the number of revolutions fixed from the standpoint of the generator desired to be furnished. In some few cases these speeds are found to be correct, but in many cases they have been arrived at from some catalogue speeds and powers which are approximately near to the estimates of the purchaser. A very superficial study of the possibilities of the modern high-speed turbine runner will show how absolutely it is unfitted for high efficiencies except under exact conditions of head and speed—a comparatively slight variation in either being fatal to the very theory upon which these runners are designed; nevertheless, so great is the temptation in competition to reduce weights and prices by means of the use of high speed that this design is often recommended, even by engineers who should know better, for conditions under which its use is undesirable and even impossible.

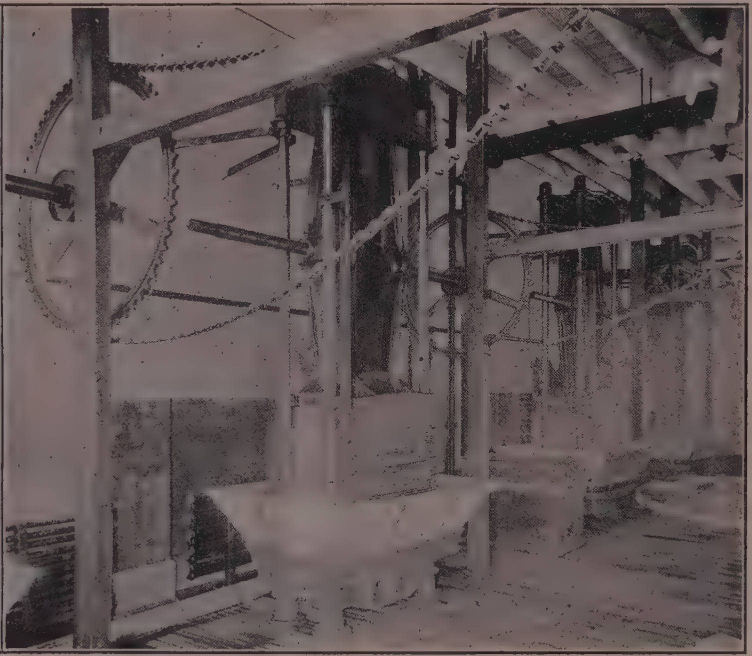
In designing a hydraulic installation, the head and quantity of water being known, the size of wheel and number of revolutions best suited for high efficiencies can be determined. If only the hydraulic part of the installation were to be considered this would require little co-operation between the manufacturers of the various parts of the equipment. But there remains other questions to be considered, as, for instance, the number of units to be used. This will largely be determined by what the power is to be used for. In some cases large units would be better than a larger number of smaller units. In this determination consideration will be taken of the point as to whether or not the size of unit results in using a standard or special type of generator. If the limits of speed proposed in the turbine do not quite permit of a standard generator, the use of a different *specific* speed in the *design* of the turbine runner will often permit of the use of a standard generator and still preserve in the turbine the high efficiencies required under varying conditions of head and volume of water available and power required, resulting in a decided economy, both in first cost and in amount of water used in operation —an important item to the purchaser.

It is true that up to this point it can be argued that the work is that of the consulting engineer and not properly in the province of the manufacturer. This argument, however, is born of the lack of opportunity in the past to discuss these features as a whole with the manufacturer. If the manufacturer were equally interested with the consulting engineer and the purchaser in the actual results of the installation as a whole, the results achieved would be easily determined and the responsibility fixed. Instead of usurping any of the functions of the consulting engineer, such a manufacturer should be of invaluable assistance, both in determining the type of plant best suited for the installation as well as the details of manufacture, assembly and installation, and also in determining, without prejudice, the value of the results achieved.

A most important point in the design and manufacture of hydro-electric installations, and one which unites the different parts of the design into one problem, is the question of governing. In spite of all that has been written and emphasized in connection with the governing problem of hydraulic plants, it must be admitted that common practice in this connection is directly contrary to the results of experience. Specifications *ad infinitum* are prepared and issued, specifying the results to be achieved by the governor without any notice being given or importance attached to either flywheel effect, inertia of water in penstock or draft tube, action of relief valve and other elements, all of which have a direct bearing upon what it is possible for a governor to do. With the specifications, separate bids are asked for the governing apparatus. The prevailing impression seems to be that all that has to be considered is the movement of the gates of the turbine within a given time. If there is one element in a hydro-electric installation which must be considered in connection with all the other parts of the generating station, and which should be designed and furnished by the turbine manufacturer, it is the governor. The rotating parts of the generator and turbine, the relief valve, the penstock and draft tube, are as much a part of the governor as the fly balls themselves.

If the entire installation were designed, manufactured and guaranteed as a whole, all elements connected with the question of governing would receive proper consideration in design, and the difficulty of determining results would be practically eliminated. There would be no further necessity for determining the efficiencies of the generator, turbine, exciter and exciter turbine separately, with the necessary allowance for thrust bearing friction, governor drives, and other losses, as at present. The same efficiency would be required, but would readily be measured by actual electrical output, and once determined there would be no shifting of responsibility in case of failure.

Cattle Pens and Sprinklers on Roof of Abattoir Building.

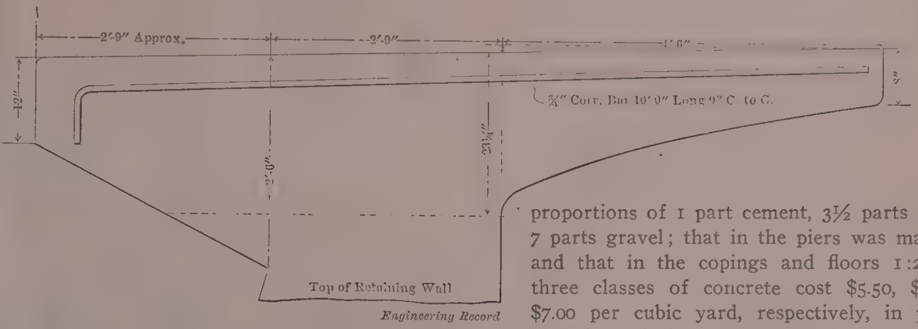


The Filtering Presses in the Fat Rendering Plant.

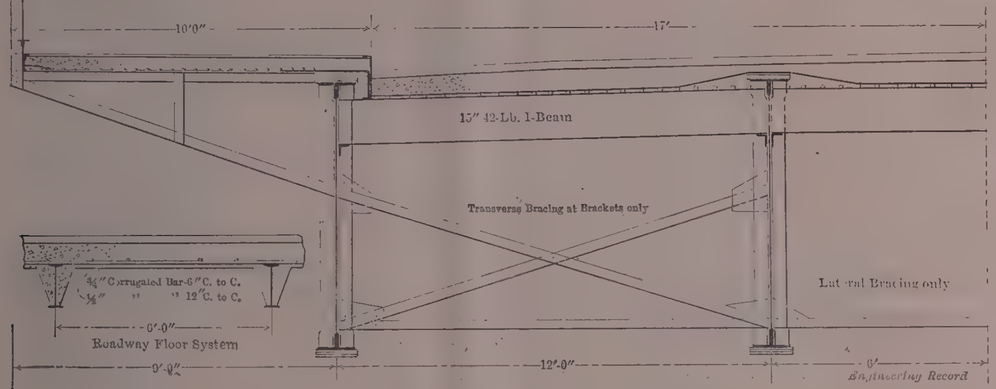
The Colfax Avenue Bridge, South Bend.

A 770-ft. deck plate-girder highway bridge with a reinforced-concrete floor system, was built in 1904 to carry Colfax Ave., in South Bend, Ind., over the St. Joseph River. The street crosses the stream at an angle of 45 deg., the bridge having three 90-ft. skew spans over the channel and six 60-ft. straight spans on one side of the channel. The bridge is carried on concrete piers and abutments, the piers under the skew spans and the abutment at one end of the bridge being built parallel with the stream. The bridge has a 34-ft. roadway, with a 10-ft. walk on each side, the roadway and walks being on a 2¾ per cent. grade. The roadway is designed to carry a uniform live load of 150 lb. per square foot, with a rolling load equal to a 20-ton road roller having its weight distributed according to Cooper's Class A loading.

The roadway is carried by four longitudinal girders, spaced 12 ft. apart on centers, as shown in the accompanying cross-section of the structure. The girders of the 90-ft. spans have webs made of ⅜ x 89¾ in. x 30-ft. plates, with two 6x6x⅜-in. angles and a thickness of plates varying with the moment forming each flange. The 30-ft. web plates are joined with a ⅜x3½x5-in. angle and a ¾x14-in. filler on each side of the joint. The floorbeams are 15-in., 42-lb. I-beams. These beams are placed 6 ft. apart on centers and are carried at each end by a 3½x5x⅜-in. angle riveted to the web of the roadway girder. One end of one of the 60-ft. spans is on a skew so that the four girders of this span were built specially. The girders of the remaining 60-ft. spans have ⅜x59¾-in. webs, but are otherwise the same as the girders of the 90-ft. spans. The girders of the various spans were designed with 12 ft. as a unit of measure in order to simplify the shop work by duplication of parts.



Cantilever Sidewalk on Retaining Wall.



Half-Cross-Section of Colfax Ave. Bridge.

The sidewalks are on brackets cantilevered out from the roadway girder on each side. These brackets are 12 ft. apart on centers and carry the sidewalk and a railing along the side of the latter. The concrete sidewalk slab has a span of 12 ft. between the brackets. It has a thickness of 6 in., having 5 in. of 1:3:6 gravel concrete and a 1-in. surface coat of 1 to 1 mortar. This slab is reinforced with ½-in. Thacher bars, placed longitudinally 4 in. apart on centers.

The concrete floor slab of the roadway has a span of 6 ft. between the transverse floorbeams. It has a maximum thickness of 9½ in. at the center of the roadway, which thickness is gradually reduced to 7½ in. at each side of the roadway. The slab is reinforced transversely with ½-in. Thacher bars, placed 12 in. apart on centers, and longitudinally by ¾-in. bars, 6 in. apart on centers. The upper flanges of the roadway girders extend up into the concrete slab, so the transverse reinforcement rods are bent up over these flanges.

An expansion joint is provided at both ends of each span, but otherwise the reinforced-concrete floor is without joints. One end of each girder of the 90-ft. spans is fixed, while the other end is on a nest of nine 2½x18-in. rollers. All other girders have ⅞-in. bed and sole plates with planed surfaces having channels carrying sliding plates to provide for expansion and contraction.

The bridge has eight concrete piers, four of which are in the river and are built with the usual solid section. The other four are made up of four small piers one under each roadway girder, with small arches joining the tops of these small piers, the whole structure being on one footing. The piers of solid section are the three skew piers in the river and the first straight pier under the 60-ft. spans. They are respectively 24 ft. 2 in., 26 ft. 7¾ in., 29 ft. 2 in., and 30 ft 3⅜ in height from the bottom of their footings to the tops of bridge seats. The skew on which these piers are built and the grade of the roadway make a different elevation for the four bridge seats on each end of the skew spans; the top of each of these piers is built level and small concrete pedestals are built on it to provide for the difference in the height of the bridge seats. The cut-waters of the piers are shod with a 7-in. T-rail imbedded in the concrete. The other four piers are respectively 16 ft. 10¾ in., 26 ft. 3 in., 24 ft. 7 in., and 29 ft. 11 in. in total height. The concrete arches which tie together at the top the four small piers in each of these four main piers are reinforced with seven lines of ¾-in. Johnson corrugated bars, placed horizontally over the arches. These bars extend from the small pier on one side to the small pier on the other and are turned down into the concrete of these end piers for anchorage.

One of the abutments has a wing wall 35 ft. long on one side and one 94 ft. 4 in. long on the other, both wing walls being at right angles to the abutment and one under each of the sidewalks. Over these wing walls the sidewalk is carried on a reinforced-concrete slab, cantilevered out from each side of the top of the wall. The details of this construction are also shown in one of the illustrations. On one side the slab is cantilevered 4.5 ft., while on the other side the cantilever is only 2.75 ft., the side with the greater overhang being anchored back to the wall and to the other side by ¾-in. Johnson corrugated bars, 9 in. apart on centers.

No unusual difficulties were encountered in the construction of the bridge masonry, nor in the erection of the superstructure. The excavations for the channel piers were made in sheeted pits. These piers are on piles driven in the bed of the river by a drop-hammer pile driver on a scow. The concrete for the channel piers and the east abutment was mixed in a Smith mixer set up near the latter. A hopper was built up over the mixer and the sand and gravel handled between storage piles and this hopper in a bottom-dump bucket by a stiff-leg derrick. The concrete was hauled out to the channel piers in small dump cars on a track on a trestle built across the stream. The concrete in the abutment and the 4 piers on the opposite side was made in the same mixer set up on that side of the stream. The concrete in the footings was made in the proportions of 1 part cement, 3½ parts sand and 7 parts gravel; that in the piers was made 1:3:6 and that in the copings and floors 1:2:4. The three classes of concrete cost $5.50, $6.30 and $7.00 per cubic yard, respectively, in place. It is estimated that the arch and small pier construction in the four piers enabled a saving of $2,000 to be made as compared with the cost of solid main piers.

The bridge was designed and built under the direction of Mr. A. J. Hammond, city engineer of South Bend. The superstructure work was carried on by the Lafayette Engineering Co., Lafayette, Ind., the contract price being $59,200. The sub-structure was built by the Savage Construction Co. for $24,089.

AN AFRICAN RAILROAD has been placed in operation recently that will materially change the transportation conditions in South Africa and greatly affect many different centers of industry. The new line extends from Fourteen Streams, which is 698 miles north of Cape Town on the border of Cape Colony and the Orange River Colony, north of Kimberly to Klerksdorp in the Transvaal, near the Orange River Colony. While the new railroad is only 114 miles long, it reduces the distance by rail between Kimberley and Johannesburg, where the diamond fields and gold mines are respectively located, from 661 to 331, and enables a saving of 22 hr. to be made in the journey between these two cities. The distance between the Kimberley mines and the immense coal fields of Natal and the Transvaal is also shortened the same amount. The new connection at the same time reduces the rail distance between Cape Town and Johannesburg 56 miles, or from 1,013 to 958 miles. When the track and roadbed have seasoned it is expected that an average speed of 30 miles an hour can be maintained on the new road, so that the present running time between various places will then be farther reduced. Modern equipment and rolling stock, including dining and sleeping cars, are used on the new road and on the various railroads with which it connects. A modern Pullman coach constructed in this country was recently sent out in sections to South Africa and assembled there for use on the railroads leading to the interior. The construction of the new line was started in March, 1905, and trains were first put in operation over the new tracks in April last.

The Electrolytic Corrosion of Structural Steel.

A paper read at the ninth general meeting of the American Electrochemical Society by Maximilian Toch.

Engineers have commented publicly on the electrolytic corrosion of structural steel, particularly those parts known as grillage beams supporting columns and base posts, which are either in the ground or surrounded by concrete and partly above the ground, with a view to determining beyond question at which of the poles corrosion occurs and whether one pole is more active than the other. A series of experiments were started since the last meeting, and definite results have been obtained.

The first experiment was performed by taking two sheets of high-grade watch-spring steel, which is extremely susceptible to corrosion, and connecting them with the ordinary blue stone telegraphic cell. A volt-ammeter was placed in the circuit, and the two pieces of steel buried up to 5 in. in sand. Careful observation was made every day to see that the current was uniform; the sand was first moistened with salt water, and then continually moistened with distilled water, so that the same strength of salt solution was maintained.

This experiment was conducted for one hundred days, and, assuming that the current travels from plus to minus, or from anode to cathode, the anode being connected with the copper and the cathode being connected with the zinc, corrosion was noticed almost immediately at the anode, and the plates showed violent corrosion at the anode and practically no corrosion at the cathode.

The strength of the current was 0.05 volt, the distance between the plates, in the damp sand, was 1½ in., and the amperage varied from 0.02 to 0.05. The current was measured by a Pignolet direct reading, continuous current, volt-ammeter, and the amount of current which produced this corrosion was exceptionally small.

The next experiment was tried in exactly the same manner, for a shorter period of time, but instead of using two plates three plates were used, the third one being designated as the "free" plate in which chemical corrosion had full sway. At the end of six days, these plates were removed. The anode showed marked corrosion, the cathode plate showing practically no corrosion at all, and the "free" plate showed a fair average between the cathode and the anode, and it can be deduced that the difference between the cathode and the anode corrosion is equal to the "free" corrosion. In other words, there is many times more corrosion on the anode than there is on the "free" plate, and no corrosion on the cathode plate.

The plates were very carefully varnished all over to preserve them, after the experiments were completed. The rust produced was first the green ferrous oxide $Fe\ (OH)_2$ which, being a very unstable product, was quickly converted in the air into $Fe_2O_3H_2O$.

The current which produced the result was 0.1 volt and 0.1 ampere. The salt solution was four times as strong as that produced in the first experiment.

The third experiment was of the greatest importance, owing to the fact that the author attempted to imitate the conditions as they existed in buildings. The same kind of steel was taken and imbedded in various mixtures of concrete, starting from neat cement and going up to 1:3:5.

There is a well-known law in physical chemistry that reactions which take place with an increase of pressure are retarded by an increase of pressure, and the question has come up as to whether it is possible for steel to corrode when surrounded by concrete, many engineers holding that the alkaline nature of the cement will prevent the corrosion, and others holding that in conjunction with this condition, the pressure exerted by the concrete prevents chemical decomposition. The author is glad to be able to throw some light on this subject, and the following experiment was carried out:

In the first place, cement was taken of known composition, agreeing practically with the definition as quoted in the Journal of the American Chemical Society, Vol. XXV, No. 7, 1903, when the question of the permanent protection of iron and steel by means of cement was thoroughly gone into. The cement for these experiments was what might be termed the tri-calcic silicate and calcium aluminate. This is in contradistinction to the general classes of Portland cements containing dicalcium ferrite as a part of their composition and free calcium sulphate in excess.

A cement of the calcium aluminate class free from iron and free from calcium sulphate is a well-known protector of steel. The pieces of steel were connected up with six elementary cells of sufficiently high voltage and amperage, and it was impossible to get a direct reading from the volt-ammeter, the instrument being too sensitive. The seven blocks containing the steel strips were then put into the circuit and wet every few hours with solutions of 5 per cent. sodium chloride and 1 per cent. nitric acid and water, in order to increase their conductivity and produce corrosion as rapidly as possible.

The volt-ammeter then gave the following reading: The average strength of the current was 0.05 volt and 0.05 ampere throughout the entire experiment. Corrosion was immediately noticed on the anode pole, and the block made of neat cement, which should have protected the steel most perfectly against all kinds of corrosion, showed a hair-line split colored with rust at the end of the third day, which demonstrated that the chemical reaction of rusting had taken place at the anode; that the molecular increase had likewise taken place, and the pressure caused by the molecular increase had split the block.

The steel in each alternate block was painted half the length, which was embedded in the cement with an insulating paint of known composition having a voltage resistance of 625 volts per millimeter. The results obtained after these various briquettes were broken open, demonstrated that electrolytic corrosion takes place most violently at the anode, unless the steel be coated with an insulating medium. Cement, concrete, or even neat cement, is therefore no protection against electrolytic corrosion unless the steel be insulated as heretofore mentioned, and there was absolutely no corrosion where coated with such insulating material. It must be noted that the cathode in all these experiments was perfectly free from any signs of oxidation.

The result of this entire series of experiments is to prove conclusively that electrolytic corrosion of structural steel embedded in concrete or sand takes place only at the anode, and there with great violence; and furthermore, that the cathode is protected by the electrical current. The popular impression that cement is a protector against corrosion of all kinds is fallacious, and the anode not only rusts very violently, but a molecular increase of volume may take place which will split the concrete shell. Another conclusion arrived at is that the electrolytic rusting of grillage beams of buildings need not be feared if the structural steel be protected by a good insulating material; but the insulating medium should form a bond with concrete.

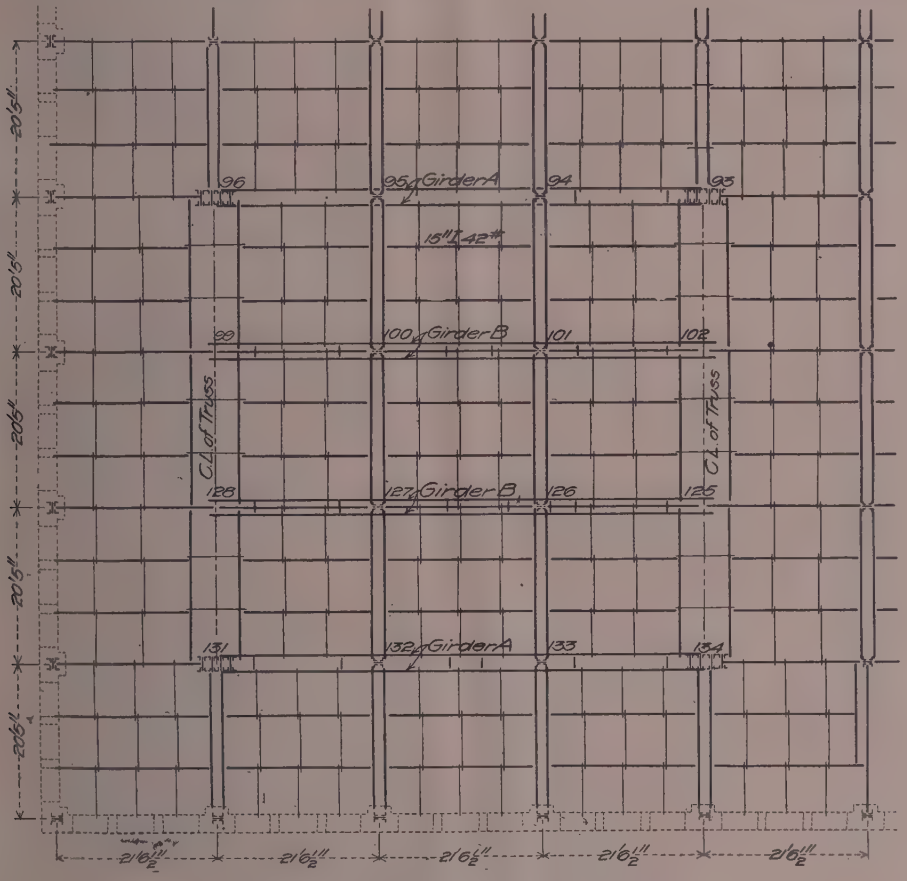
Cantilever Concrete Sidewalk and Arched Piers, Colfax Ave. Bridge.

A Motor-Driven Pulp Mill, involving two three-cylinder pulp mills direct driven at 300 r.p.m. by a single 800-h.-p. Westinghouse two-phase motor, has recently been placed in operation at Niagara Falls, N. Y. The mills have grindstones 30 in. wide and grind 28-in. wood, each mill having three 14-in. hydraulic cylinders which force the wood against the stone. The motor is placed between the mills in a waterproof brick enclosure through which the mill shafts are extended for direct connection to the motor on either side. Electric power is supplied by the Niagara Falls Power Co., at 2,200 volts, the current being delivered to the motor direct without transformation.

Some Steel Details in The Wanamaker Building, New York.

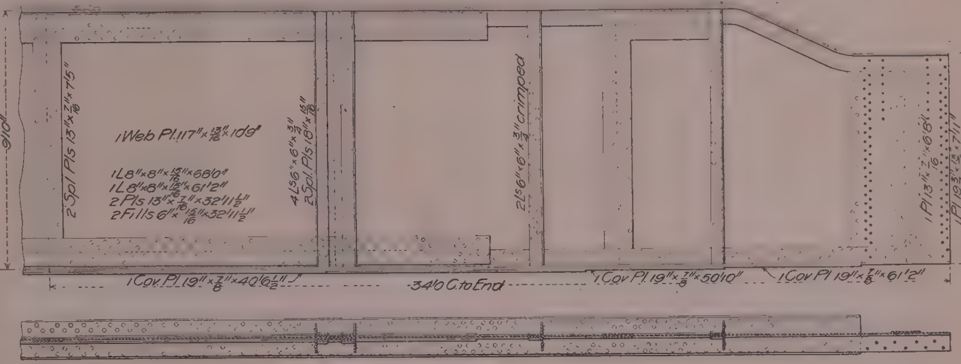
The new department store building for John Wanamaker, occupies the block bounded by Broadway, Fourth Ave., Eighth and Ninth Sts., and is nearly rectangular in plan, with fronts of about 355 and 188 ft. It has a height of 219½. ft. from street level to top of cornice, or thirteen stories and attic above the curb and two stories below the curb, and is lighted by windows on all sides, by skylights and by a 63x60-ft. rectangular court in the center, extending from the roof to the first story. The court has a skylight at the roof level and a glass dome at the eighth floor. The building is of standard fireproof steel-cage construction having tile floors and partitions and masonry walls supported by wall girders in every story. The flat tile roof is proportioned for a live load of 50 lb. per square foot and the floors are calculated for live loads of 120 lb., except in the first story and above the seventh story, where 150 lb. is used in the design.

All columns are carried to bed rock by concrete piers. Cast-iron bases and steel grillage beams are used to distribute the loads of the columns to the concrete piers, and cast-steel bases are used under the large columns at the corners of the Music Hall. One of the principal features of this building is a passenger station for the subway of the Rapid Transit R. R., which is located in the basement at the corner of Fourth Ave. and Eighth St.



Part Plan of Fifth Floor Beam Framing.

The framework is carried by 161 main columns aranged in ten longitudinal rows 19 ft. 7 in. apart and in sixteen transverse rows 21 ft. 6½ in. apart. All of them are of ordinary H-shaped cross-section made of four flange angles and a solid web plate, except in the case of four special columns carrying heavy girders and trusses, which have closed rectangular cross-sections. The beam framing is very regular and consists in general of pairs of 15-in. I-beams forming transverse girders which carry intermediate lines of single 15-in. longitudinal I-beams about 22 ft. long and from 5½ to 7½ ft. apart except where special arrangements are required for stair and elevator shafts. The Broadway and Fourth Ave. walls are carried by plate girders with angles or channels bracketed to their outer faces. The Eighth and Ninth St. walls are carried by 18 and 20-in. I-beams and 15-in. channels. The walls of the light court are carried by plate girders 26 in. deep, with a pair of 5x3½-in. shelf angles bracketed out from their webs. Most of the connections are of standard types and great pains were taken to secure regularity so that a large proportion of the pieces are duplicated very many times, thus simplifying the shop work and erection.



68-Foot Girder in Fifth Floor.

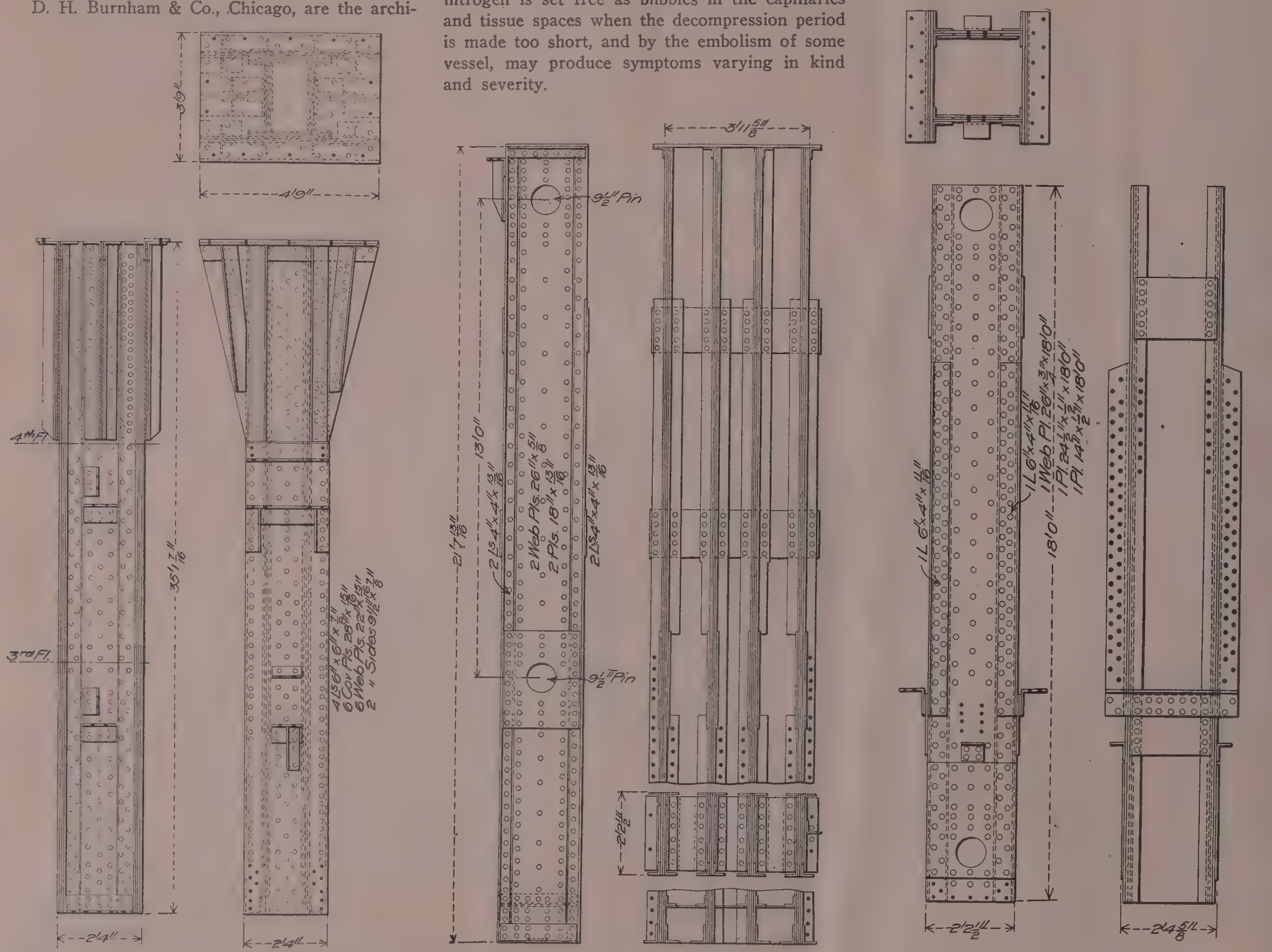
Near the Ninth St. and Fourth Ave. corner there is, in the second story, a very large hall with its floor unobstructed by columns. In order to provide for this wide clear space about 108 ft. long and 60 ft. wide, the fifth floor and all the stories above it in fifteen regular panels are chiefly carried by four main columns at the corners of a 64½x60-ft. rectangle. Each pair of these columns support one transverse truss, 64 ft. 7½ in. long and 16 ft. deep on centers, which is contained in the fourth-story partition. The floor between these trusses is carried by four double longitudinal plate girders about 69 ft. long, and the floor panels adjacent to the trusses on the opposite sides from the girders have the ordinary longitudinal I-beams supported at one end by the trusses and at the other end by the regular transverse girders.

The trusses have end vertical posts seated about 5 ft. 8 in. above the fourth-floor level on the caps of special columns, the largest of which is designed for a total load of 5,270,000 lb. The columns are nearly duplicate and are made, as shown in the accompanying detail, with six cover plates and eight web plates, giving an aggregate cross-section of 352 sq. in. The upper ends of the columns are milled and have vertical and inclined bearing angles and gusset plates supporting the 45x57-in. cap plate. Each truss weighs about 400,000 lb., and has very massive pin-connected members. The top chord is made in a single piece and has three webs in the center four panels. In the end panels there are only two full-length webs, but there are center diaphragms at the end pin connections. Each chord section was riveted up complete in the shops. The end posts, a little more than 20 ft. long, project over 7 ft. below the end lower-chord pins and virtually form pedestals, integral with the truss, which support it on the main columns. Each post is made with four webs fastened together by tie plates on both flanges, but not having cover plates. It has a net section of 307 sq. in., and is proportioned for a total stress of 1,980,000 lb. The intermediate verticals and the principal diagonals are riveted members. The other diagonals and the bottom chords are 10-in. eye-bars.

Each of the intermediate diagonals are made with a pair of rolled or built channels with the flanges turned in and latticed. The end diagonals are made with three webs and have bearings on the end pins. Intermediate vertical posts have rectangular cross-sections and are provided with special vertical flange angles and horizontal shelves for the field-riveted connections of the intermediate transverse girders. The latter are pairs of massive single-web plate girders about 11 ft. deep at the center, spaced 2 ft. 5 in. apart on centers, and having their webs projecting through the trusses so as to engage double rows of vertical field rivets in both flanges of the truss vertical posts, as indicated by the open holes in the drawings of both members.

The top flanges of the girders are beveled downwards at the center so as to afford clearance for the top chords of the truss. Each girder carries two columns, about 10 ft. 9 in. on each side of the center, each of which is nine stories high and imposes a load of 820,000 lb. on the girder. The girder web is 13/16 in. thick throughout and is reinforced on column centers by four 6x8x¾-in. angles, which virtually extend the column section across the full depth of the girder with faced bearings on the girder flange angles. Between these bearings and for a short distance beyond them the flanges are reinforced by pairs of 13x7/16-in. side plates about 33 ft. long and 6x15/16-in. filler plates not considered as flange area. Each flange has a maximum net area of 79.5 sq. in. The end girders are similar to the intermediate ones except that their connections to the vertical posts are somewhat different, but they are also riveted across the vertical flanges of the posts. The girders are braced transversely by sixteen vertical sway-brace frames, each consisting of a pair of 6x6-in. diagonal angles and horizontal ceiling and floor-beams attached to gusset plates on the vertical web-stiffener angles.

D. H. Burnham & Co., Chicago, are the architects of the building, Mr. J. G. Giaver, structural engineer, and Mr. W. T. Lewis, resident engineer. The American Bridge Co. was the contractor for the structural steel work, which was built at their Trenton shops and was erected by John Griffiths & Son, of Chicago.



Column 93; End Vertical Post, and Intermediate Vertical Post, Fifth Story Truss, Wanamaker Building.

Another Water Tank Failure occurred on June 8 in Pittsburg. The tank was on the roof of a building apparently unable to support its weight, for the failure had the nature of a collapse rather than the sidewise wrench which usually occurs when the tank itself gives away. Nine people were injured, most of them by falling a couple of stories in a shower of debris. So much has been said lately in this journal about the danger threatened by such tanks unless they are properly constructed and supported, that there is no necessity of dwelling on the lessons of this accident.

Investigations of the Effect on Man of High Air Pressures.

The researches of Paul Bert, confirmed in recent year by Von Schrötter and his co-workers, and also by Leonard Hill and J. J. R. Macleod, have demonstrated that the ill results observed in caisson workers and divers are to be attributed to injudicious rapidity of decompression. Experiments on animals have shown that every 100 c.c. of blood or tissue fluid dissolve, at body temperature, about 1 c.c. of nitrogen under one atmosphere of air; 2 c.c. under two atmospheres; 3 c.c. under three atmospheres, and so on. This nitrogen is set free as bubbles in the capillaries and tissue spaces when the decompression period is made too short, and by the embolism of some vessel, may produce symptoms varying in kind and severity.

Dr. Hill having determined, by numerous experiments on animals, that no ill effects follow exposure to pressures up to seven atmospheres, if 20 minutes be allowed to each atmosphere for decompression, he and Dr. M. Greenwood, Jr., determined to investigate the effects of high pressures of air upon themselves. The experiments and conclusions were described recently in a highly important paper before the Royal Society, from which the following notes have been taken:

The records of caisson works and the operations of deep sea divers show that owing to the rapid rates of decompression at present employed by engineers and divers, very great risk is incurred by workers in caissons at pressures of 3 atmospheres, and by divers at depths of from 100 to 150 ft. As, however, divers usually stop a very brief time, while caisson workers outstay a shift of from 2 to 4 hours, the body fluids of the latter become saturated with nitrogen, hence their greater danger at lower pressures.

The limit for practical diving work is fixed by the great increase of mortality and illness which occurs at depths much exceeding 100 ft., while at less depths than this, accidents are by no means infrequent, being occasionally very severe or fatal in character. The Admiralty set 120 ft. as the limit of work for their divers, while the most daring pearl and sponge fishers sometimes reach depths of 145 ft.; in this latter group accidents are numerous. Lambert, the famous diver employed by Messrs. Siebe & Gorman, salved £100,000 at a depth of about 160 ft. On each descent he passed about 20 minutes below, and about the same time in ascending. On the last journey he stayed longer and became affected on his return to the surface, permanently losing the power to retain his urine. Lambert was the man who stopped the flooding of the Severn Tunnel, going through the tunnel (dark and full of water) in a Fleuss dress to a distance of a quarter of a mile from the shaft, and closing the flood gates, which had been left open; his courage deserves to be recalled. Another diver, Erostabe, salved treasure from a depth of 171 ft., and yet another, Ridyard, from 160 ft. These three divers of Messrs. Siebe & Gorman hold the record for successful work carried out at great depths. Two other divers of the same firm, in order to test a patent kind of diving apparatus, descended to 189 and 192 ft. respectively. One of these divers (Walker) was about 50 minutes over the job, taking 30 minutes to ascend.

He ascribes his immunity from accident throughout his career as a deep diver to his habit of slow ascent. The deepest dive on record is one of 204 ft. (88½ lb. pressure); the diver who made this record died from the effects of too rapidly mounting to the surface.

In 1894, at Bordeaux, H. Hersent, an engineer in charge of caisson works, having first experimented on animals, found three workmen willing to submit themselves to high pressures of air. These men were enclosed in a steel chamber, and the experiments were conducted under the observation of a commission composed of five members of the Bordeaux Faculty of Medicine. Two of the workmen had had previous experience of compressed air.

In one experiment the subject was compressed to 4.800 kilos. per square centimetre (68.27 lb. per square inch) in 35 minutes, remained under this pressure 1 hour, and was decompressed in 2 hours 3 minutes. On quitting the chamber the man experienced a few "picotements," which lasted for half an hour, but no other unfavorable symptoms. In a second experiment, a pressure of 5,000 kilos. (71.16 lb. per square inch) was attained, without any subsequent ill effects beyond a few "picotements." Finally, the same subject was compressed to 5.400 kilos. (76.81 lb. per square inch) in 45 minutes, remained under the pressure 1 hour, and was decompressed in 2 hours 25 minutes. The effects are recorded in these words: "A ressenti peu de picotements, cela tient aux bains sulfureux pris les jours précédents."

Hersent's experiments justify his conclusion that "avec quelques précautions en sus de celles qu'on prend ordinairement, les hommes peuvent être comprimés et décomprimés sans danger pour leur vie, et que même leur santé n'est pas menacée quand on atteint des pressions allant jusq'à 5 kg. 400."

Hersent and his medical colleagues do not appear to have entered the pressure chamber themselves, so that we are not in possession of an accurate record of the subjective effects as noted by trained scientific observers. One of the objects, therefore, of the experiments of Drs. Hill and Greenwood, has been to study in detail the subjective and physiological changes induced by greatly increased barometric pressures; another object has been the investigation of the respiratory exchange under the same conditions.

The experiments have been carried out in a steel cylinder placed at their disposal by Messrs. Siebe & Gorman. This cylinder had a capacity of 42.2 cu. ft., and was provided with a mattress, blanket and pillows, enabling the subject to adopt a comfortable attitude. Compression was effected by means of a two-cylinder motor-driven pump, which could raise the pressure to 6 atmospheres in about 40 minutes. Two decompression taps were provided, with fine bores, permitting very careful adjustment of the rate of escape. The chamber was also fitted with electric light, bell, telephone, and a thick glass observation window: the latter, however, was subsequently covered with a steel shutter for greater security. The pressure was measured by a Bourdon spring gauge, which had been tested for correctness.

In the course of the investigation the following pressures have been attained: By Dr. Hill, 75 lbs. once, 60 lbs. twice, 45 lbs. twice, 30 lbs. four times; by Dr. Greenwood, 90 lbs. once, 75 lbs. three times, 60 lbs. four times, 45 lbs. five times, 30 lbs. seven times. In no case have any severe after effects resulted. The maximum pressure in the series corresponds to a water depth of 210 ft., which is 90 ft. beyond the limit fixed by the Admiralty for their divers.

Supposing the special diving bell designed by Dr. Hill for the slow decompression of divers were employed, it seems quite possible to the authors that work might be carried out safely at a depth of 210 ft. Even a greater depth than this might be attained by an intrepid man, for the limit appears to be fixed by the pressure at which the toxic effects of high tension oxygen become an immediate danger. These effects have been studied by Paul Bert, Lorrain Smith and Hill and Macleod. When the partial pressure of oxygen reaches 2 atmospheres (corresponding to 10 atmospheres of air, or a depth of about 350 ft. of water) convulsions may occur in animals within 20 minutes. The limit of possible safe working is therefore about 250 ft. Conceivably this limit might be extended by diluting the air with nitrogen so as to lower the partial pressure of the oxygen, but the authors do not claim more than that their experiments show the safe diving depth may be increased up to 210 ft.

The responsibility of those who allow short decompression periods in caisson works is clear; every death or case of paralysis from air embolism must be set down to the negligence of the contractor.

As to the sensations felt under pressure, the feeling of discomfort in the ears and deafness, due to a difference in air pressure within and without the tympanum, is too well known to need description. Owing probably to a catarrhal condition, neither investigator was able to open his Eustachian tubes by merely swallowing, and was compelled to resort to a forced expiratory effort with mouth and nose shut, the latter being held tight by the finger and thumb.

The sense of hearing was as acute and, in the opinion of Dr. Hill, more acute than normally. The signal of a tap with an iron spanner on the outside of the chamber was painful in its intensity to him. Apart from the feelings of nervousness at being exposed to so high a pressure, the investigators could not detect any real sense of pressure, and certainly noticed no abnormality in their bodily functions, with the trifling exception of the voice.

The voice changes, observed in all caisson workers, were well marked in these tests. The alteration is distinct at 1 atmosphere, and very marked at 3 atmospheres. The voice has a peculiar nasal and metallic quality, losing the individual characteristics of the speaker. Thus to Dr. Hill, when speaking in the chamber, under pressure, his voice appeared like that of Dr. Greenwood under pressure. At 3 atmospheres the power to whisper or whistle is almost entirely lost. Dr. Hill, who retained the power somewhat longer than Dr. Greenwood, could just make an audible whistling note at this pressure. This loss of the fine vibratile movements of the tongue and lips, a loss probably resulting from the damping effects of the dense air, leads to a false sense of anæsthesia in the former parts. This conception of anæsthesia is interesting, as being solely excited by a lack of normal movement.

V. Schrötter and others have laid stress on the diminished frequency of the pulse and lowered blood pressure of caisson workers. The observations of Drs. Hills and Greenwood were not sufficiently extensive to permit of any final pronouncement; but, so far as they go, these investigators were unable to detect any definite change in the pulse frequency.

They came to the conclusion that it was an important matter during the decompression to move in turn every muscle and joint of the body, and to change one's position frequently, so as to keep the capillary circulation active in every part. In the brain, spinal cord, and abdominal organs this circulation is kept active by the work of the respiratory pump. In the limbs, muscles, fat of the back and chest, on the other hand, the movement of the blood and lymph back to the heart depends mostly on changes of posture and expressive action of contracting muscles.

The next stage of the investigation was devoted to an inquiry as to the changes in the percentage of alveolar CO_2 under the altered conditions, using the method described by Haldane and Priestley. The subject breathes through a wide-bored rubber tube; after a normal expiration he expires deeply and then closes the end of the tube with his tongue. A sample was taken from the wide tube into Haldane's portable CO_2 analyzer, and examined. A bench fitted up in the cylinder enabled the subject to collect and examine samples with ease. It may be remarked that it is necessary to replace the corks at the bottom of the water bath in Haldane's apparatus by well-fitting rubber ones, as the air is compressed in the corks, which leak at high pressures. Owing to the loss of the water jacket some of the earlier experiments were unsuccessful. Great care is also necessary in readjusting the potash leveling tube, as when the chamber is closed a slight fall of pressure is almost inevitable owing to escape round the washer of the door.

Haldane and Priestley have shown that the respiration is so regulated as to maintain a constant tension of CO_2 in the alveolar air, which is generally about 5 per cent. of an atmosphere. Now supposing the metabolism to be unaffected by changes of pressure, and the regulation of respiration to continue the same, the amount of CO_2 in the alveolar air must vary inversely as the pressure attained.

The authors think the results obtained in this way show so close an agreement with the theoretical values as to support the conclusion that changes in the percentage of carbon dioxide in the alveolar air depend solely upon the physical conditions. No increase or decrease in the pulmonary output of CO_2 occurs. Metabolism, then, in so far as it can be determined by an investigation of the alveolar air, is not affected by increasing the barometric pressure. It is scarcely necessary to add that this criterion is by no means adequate to sustain the final conclusion that metabolism is, in fact, unaltered by the atmospheric conditions; so far as it goes, however, it is in favor of such an inference.

The Historic Forest of Dean Iron Mine in Orange County, New York, has recently been reopened; involving its unwatering and the replacement of the old overshot water wheels and Cornish lift pump by modern equipment and methods, according to the Iron Age. This mine, which is 5 miles west of Fort Montgomery, on the Hudson River, was discovered in 1756, and the ore, a magnetite, was reduced in a charcoal furnace at the mine for some 20 years. It was reopened in 1862 and the ore mined shipped up the river to the blast furnaces at Poughkeepsie. Up to the time of discontinuance of mining in 1894, over 1,000,000 tons of magnetite ore had been taken out and work was carried to a level 700 ft. below the surface. In the new development the property holdings have been greatly extended, and a 225-h.-p. water power plant installed embracing two 72-in. double-nozzle Pelton wheels which operate an air compressor, a hoist and a 12-in. Cornish pump. Water is delivered to the wheels by a 3-ft. steel pipe, 1,000 ft. long, leading from a reservoir. The hoist and pump are driven by rope drives, and the compressor by belt, the latter being a Rand two-stage compressor with a capacity of 750 ft. of free air per min. An aerial cableway 6,300 ft. in length, has been installed for handling the ore from the mine railway to the Hudson River, and has a capacity of 23 tons per hour. It is expected that 400 tons of ore will be shipped per day to the company's furnace at Secaucus, N. J.

Underpinning the Grand Central Palace, New York.

The construction of the depressed yards for the 42d St. terminal of the New York Central & Hudson River R. R. involves the excavation of Depew Pl. to a depth of about 40 ft. for its entire width for a length of about 500 ft. A portion of this extends from 43d to 44th St., adjacent to the west wall of the Grand Central Palace. The main part of the building is seven stories high, but is about 15 ft. back of the building line, the intervening space being occupied by a two-story wing of the building with its outer wall coincident with the edge of the excavation. The seven-story outer wall is carried by a box girder in the second floor, supported on square cast-iron columns 18 ft. apart, with thin base plates bearing on brick piers with stone footings carried down about 4 ft. below the surface of the ground. Each of them has an estimated load of about 176 tons, which gives an approximate pressure of eight tons per square foot on the made ground.

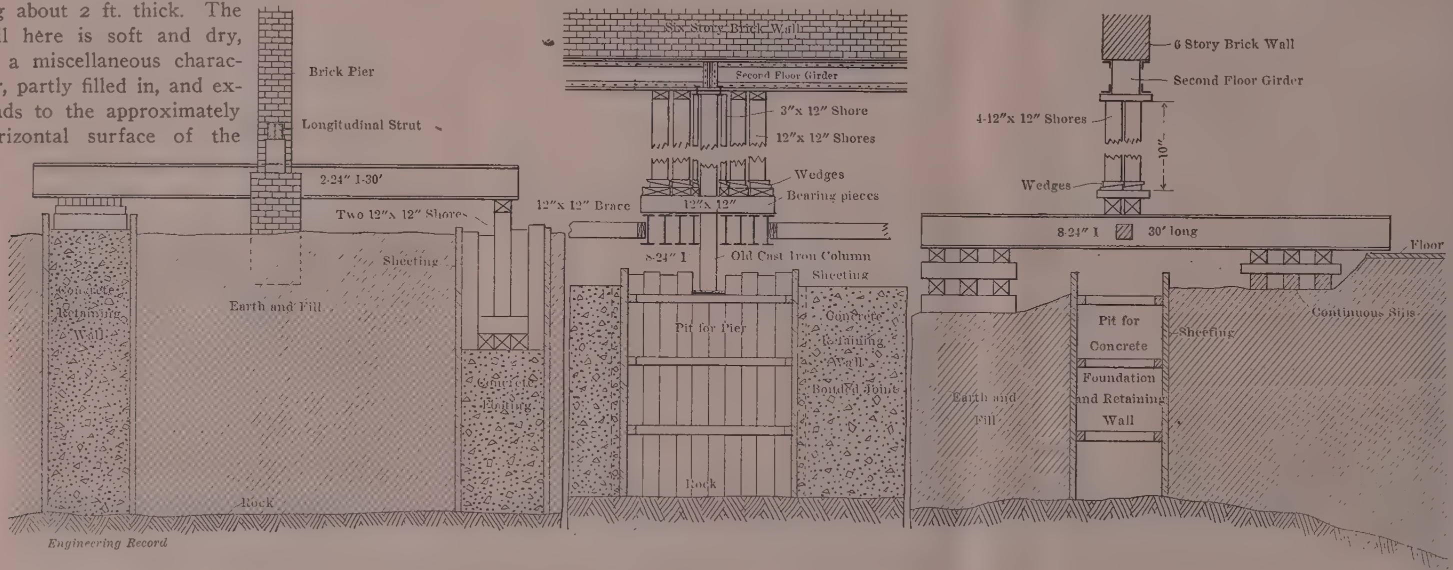
The two-story wall is pieced with arches of 6 and 10-ft. span, between which there are 2x4-ft. brick piers offset 4 in. on each side below the surface of the ground and extending down 4 ft. to a continuous footing about 2 ft. thick. The soil here is soft and dry, of a miscellaneous character, partly filled in, and extends to the approximately horizontal surface of the rock about 15 ft. below street level.

The brick walls and foundation masonry of the Palace were old and poorly constructed, so that considerable apprehension was felt for their safety, and it was necessary to support and underpin them thoroughly before commencing excavation. A careful survey of the building was made and photographs taken of critical points. Some cracks were found to exist and were sealed by strips of paper pasted over them. The seven-story wall was first underpinned with concrete foundations carried down to the surface of the rock and made continuous between column piers so as to serve as a retaining wall.

The first operation was to excavate sheeted pits about 5 ft. wide, 12 ft. long and 15 ft. deep in the center of each panel between the cast-iron columns. The building possesses no basement or cellar, and these pits extended from the first floor to the surface of the rock. They were filled with 1:3:6 Vulcanite Portland cement concrete mixed in a Smith machine. The sheeting served as forms for the concrete, which has a uniform thickness at the top and bottom, and was left permanently in position. The ends of each section of concrete were made with a vertical groove about 1 ft. wide and 6 in. deep to provide for the tongue and groove bond between these sections and the intermediate ones which were made later.

A portion of the first floor was removed and the earth under it was leveled to receive three continuous lines of 12x12-in. longitudinal timbers about 12 ft. clear of the inner face of the seven-story wall. On these sills timber cribwork was built up 2 or 3 ft. high and corresponding cribs were built opposite them on the leveled ground close inside the two-story wall of the building. These cribs supported four 24-in., 80-lb. transverse I-beams 30 ft. long, set close together on each side of each cast-iron column. Distributing pieces were set across them in the plane of the wall and on them was set, on each side of each column, a double pair of 12x12-in. vertical posts with 6x12-in. transverse caps bearing against the lower flange of the box girder.

Additional 12x12-in. temporary vertical shores were set just outside of these shores and hydraulic jacks under them were operated to lift the box girder slightly. As fast as this was accomplished pairs of wedges under the permanent shores were driven up to take all the slack, and the weight of the wall was thus gradually transferred to the 24-in. I-beams. When this was accomplished the jacks were removed and excavation was begun under and around the old column piers, extending from section to section of the new concrete retaining wall.



Engineering Record

Needlebeams Supporting Box Girders in Six Story Wall.

These excavations were sheeted and carried down to the surface of the rock, the old piers were removed, and the cast-iron columns were left suspended from the box girders by bolts through their cap plates. The pits under the columns were then filled with concrete which bonded with the sections already built and with them made a continuous retaining wall. Connection was made between it and the columns, in the usual manner, with pairs of wedging stones.

For greater security the centers of the box girders were also supported by vertical posts on the tops of the intermediate sections of the retaining wall, and inclined posts from the feet of these verticals were wedged up to bearing against the girders near the columns to provide additional support in case of any settlement on the needle-beams.

At the northwest corner of the building the yard excavation had already been brought so close to the building line that it was not considered safe to support the heavy load of an elevator shaft on surface cribbing. Therefore a pit was sheeted down to rock outside the building to receive vertical shores supporting the outer ends of needle-beams inserted in holes cut in the face of the wall, which passed through the shaft and were supported at the opposite end on one set of needle-beams already described.

Rectangular holes were cut through the piers of the two-story wall at the center points, partly in the wall and partly in the foundation pier, and through each of these there was inserted a pair of 24-in., 80-lb. I-beams 30 ft. long. The inner ends of these I-beams were blocked up from the concrete retaining wall already built in the plane of the seven-story wall. The outer ends were carried on pairs of 12x12-in. vertical shores with timber grillage footings on concrete piers previously constructed for the purpose in pits sheeted down to subgrade in Depew Pl. The weight of the wall was transferred to these needle-beams in the usual manner by jacking and wedging, after which their foundation piers and the old footings were removed and new footings carried down to the surface of the rock. The brick piers were rigidly braced by longitudinal timbers spanning the arch openings just above the needle-beams and having their ends wedged against vertical bearing strips which distributed the pressure over several feet of brickwork.

On the opposite side of Depew Pl. the excavation extends to the face of the one-story brick wall of the baggage-room for the incoming trainshed. This was a comparatively light wall with enclosed steel columns 20 ft. apart carrying the roof truss. At each of these points needle-beams were inserted and the weight was transferred to them in the usual way, while the pit was sheeted down to the surface of the rock and new concrete footings were built in it to carry the wall and roof. These piers are detached, and in order to avoid the construction of a wall 15 ft. high to connect them and retain the earth underneath the floor of the baggage-room, the outer ends of the wooden floor joists are supported on longitudinal timbers carried by inclined braces having their lower ends gained into the sides of the concrete piers or supported on outside verticals or pilasters. The upper ends of these braces are beveled to bearing on transverse members forming with them three-piece arches spanning the distance from pier to pier. Under these arches the earth recedes with its natural slope to the original surface of the ground, and the floor above is supported intermediately by vertical shores wherever the latter are necessary.

This work has been designed and executed under the direction of the Engineering Department of the New York Central & Hudson River R. R. Co., Mr. W. J. Wilgus, vice-president. The Butler Bros., Hoff Co., Mr. Olaf Hoff, vice-president and engineer, are the contractors. Mr. J. Kelly is the sub-contractor for the shoring.

A Large Engine Frame.

The accompanying illustration shows the frame and slide for the largest engine of the horizontal rolling mill type built by the Allis-Chalmers Co. Two of these units were ordered some time ago for the Sharon, Pa., plant of the Carnegie Steel Co., and are now being built at the West Allis works. The engine frame and slide for the first engine was recently cast at the West Allis foundries, and has proved to be the largest and heaviest single piece ever poured in these shops. The single piece for frame and slide weighed 105 tons and is designed for an engine whose cylinders will measure 50 and 78 in. in diameter and have a stroke of 60 in.

The pattern for this single casting was 32 ft. long, 11 ft. wide and 10 ft. high, representing the work of ten pattern makers for a period of over four months. The amount of lumber used in its construction reached the surprising aggregate of 22,000 ft. The pit in which the casting was poured was 40 ft. long, 15 ft. wide and 11 ft. deep, into which were poured some 105 tons of molten metal, the pouring of which consumed some eight to ten minutes' time. Nine ladles, four with a capacity of 25 tons each, one 13 tons and four 5 tons each, were used in the operation.

Boring a 105-Ton Casting for the Frame and Slide of a Horizontal Rolling Mill Engine.

In building a rolling mill engine with a capacity like the one in question, there is a marked advantage in designing the frame and parts in a single piece for the purpose of securing the greatest possible rigidity to withstand the racking strains of rolling mill service. The remarkable size of this piece, however, required an extra ingenuity in handling during and after its production. In the first place, a weight of this kind being very exceptional, extra precautions were taken against any mishaps in the process. Three cranes with ample overload capacities and a rated aggregate of 145 tons, were used in conjunction to lift the casting from its pit. A special tackle was devised so that the lifts should be straight upward, applied at the ends of the heaviest of trussed steel lifting bars.

The casting, after being deposited beside its pit, was allowed to cool for fifteen days before the operation of cleaning it was begun. The heat still given out after approximately twenty days' cooling, could be felt several feet away from the huge mass. During the cleaning process, three men were able to work abreast inside the slide aperture while standing upright and without perceptible crowding.

In anticipation of the difficulty of handling a piece of this size, special cars, two in number, were ordered some months ago and built at the West Milwaukee works of the Chicago, Milwaukee & St. Paul Ry. One of these cars is to be used to carry the casting to its destination. In handling the huge mass after cleaning, nothing but a straight lift was attempted to load it upon the special car, which was brought to the side of its prospective burden over a special track. The car was then used to convey the casting to the shop where the machining is now going on. The mass of metal is placed on the floor of the machine shop and the heavy machine tools used in the finishing are brought to it.

The cars mentioned as being specially built for the Allis-Chalmers Co., are unique in design and appearance so that they deserve brief mention. They are the concrete results obtained from the solving of a difficult transportation problem which confronted the engine builders. The cars used heretofore for the purpose, constructed of heavy material and with capacities of from 60 to 70 tons, proved inadequate. In seeking a suitable means for overcoming the difficulty of shipping such a piece, it was learned that no single car had ever been built with a capacity capable of carrying it, so that a special car, designed particularly for the purpose, would be the only possible solution. Accordingly orders were placed for two 16-wheel flat cars of 100 tons capacity, which are the first of their kind in existence. A few details of construction showing the unusual sizes of these cars are as follows: Length over end sills, 40 ft. 2 in.; width over side sills, 8 ft. 9 in.; height, rails to floor, 4 ft. 4½ in.; wheel base, 36 ft. 2 in.; wheels, diameter, 33 in.; journals, 5½ x 10 in.; weight of car, estimated between 50,000 and 60,000 lb.; rated capacity, 200,000 lb.

Revenue From Chicago Drainage Canal Spoil Banks.

The spoil banks of the Chicago Drainage Canal are destined to become a source of considerable revenue if the plans to crush and market the stone in them that have recently been presented to the board of trustees of the Sanitary District by Mr. John M. Ewen are accepted. More than 10,000,000 cu. yd. of stone in these banks are said to be of such quality that they could be crushed for concrete aggregate, for making roads and for various other purposes. According to estimates, the stone could be crushed and delivered to wagons at a cost not to exceed 40 cents per cubic yard, if the forces of the Sanitary District carry on the work; if the crushing is done by contract 55 cents per cubic yard, on the wagon, is considered to be a fair price. The products could be marketed readily in Mr. Ewen's opinion, for $1 per cubic yard, as the price of broken stone in Chicago is now $1.55 to $1.75 per yard. He is confident that a profit of 50 cents a yard can be made by the Sanitary District, and has offered to take charge of the entire project as agent of the Trustees for 10 per cent. of the total cost of production, or 7 per cent. of the price of the stone, or 30 per cent. of the profits. The Sanitary District recently attempted to sell the stone in these spoil banks to the highest bidder, but the proposals received stated such low figures that they have not been accepted.

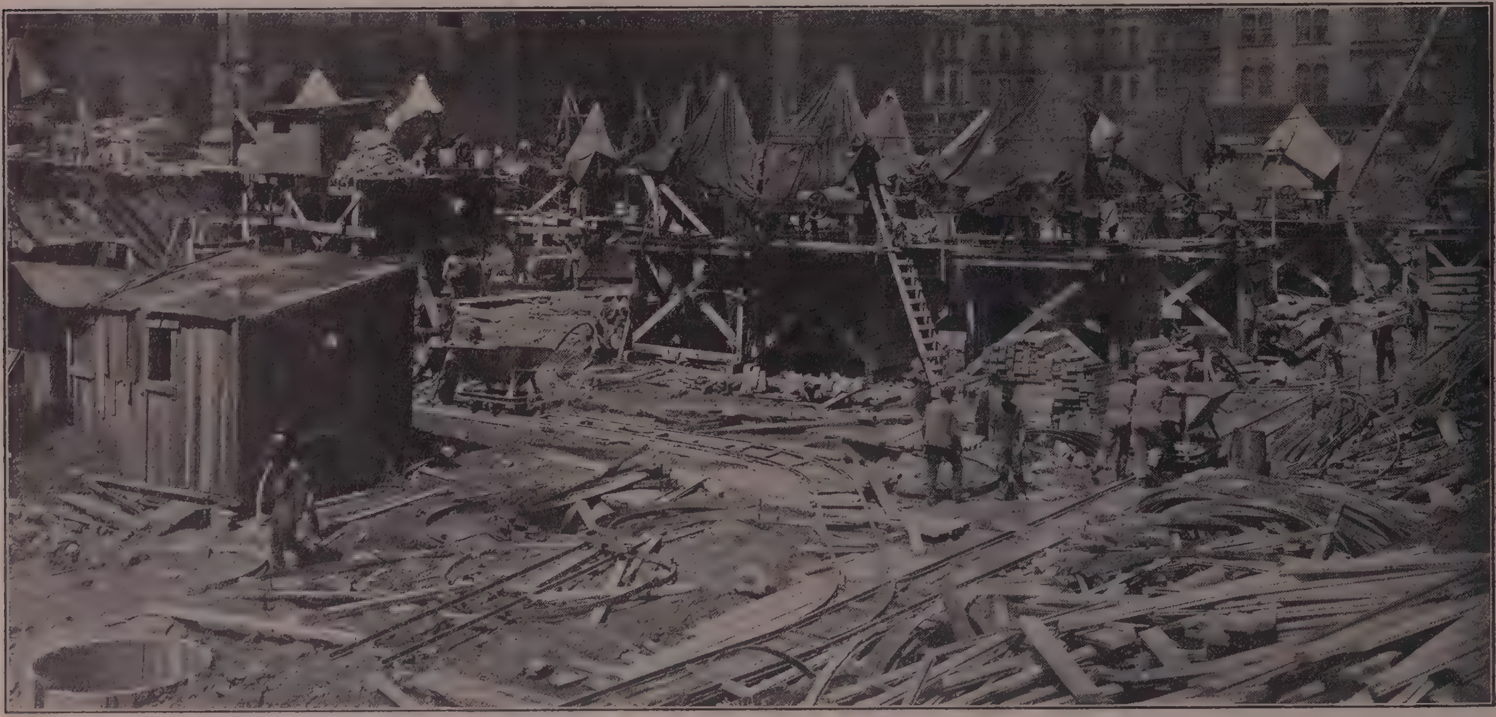
A New Water Supply is to be secured for Athens, Greece. An aqueduct consisting of masonry and steel or iron pipes will be built from Lake Stymphalos to Athens, a distance of over 100 kilometers. The work will be carried on by a company, the financial responsibility of which is practically guaranteed by the government of Greece.

Foundation Work on the Cook County Building, Chicago.

Mention has been made several times in this journal that the grillage or floating type of foundations formerly much used for important buildings in Chicago was no longer in favor, and that concrete piers running down to rock were now used quite extensively. A good example of such foundations is presented by the work on the site of the new Cook County court house at Washington, Dearborn and Randolph Sts.; this particular undertaking is also of interest because its prosecution is alleged to have caused settlement in the tottering old structure nearby which serves as a city hall.

The building will rest on 126 concrete piers put down to bed rock, their depth below the street level averaging about 115 ft. The excavation for these piers is made by hand labor. In one of the illustrations, each tent-like covering is over one of the wells where the excavation is in progress. The framework over each well is for hoisting the spoil to the surface. The bucket rope passes over a pulley at the top of the frame, and thence around a "nigger head" connecting with the outside wheel visible in the illustration. These wheels are connected in gangs by means of a wire rope, held to the proper tension by block and tackle, and driven by a hoisting engine at the end of the gang. The wells vary in diameter from 4 to 11 ft. They are lined as fast as put down, as can be seen in the lower left-hand corner of the picture, the lining being held in place by steel ribs.

When bed rock is reached the wells are filled with concrete. For this purpose a 1:3:5 mixture is used, made with Universal cement and mixed in a No. 2½ Smith mixer. The raw material is furnished to the mixer and the concrete carried away in dump cars made by the Arthur Koppel Co., and over the same company's system of portable railway. The location is covered with a complete system of these tracks, and in addition to being used to handle the concrete, the cars deliver a large amount of the excavated material to the cars of the Illinois Tunnel Co., by which it is carried away. The Geo. A. Fuller Co., contractors for the foundation work, find this outfit a valuable adjunct in facilitating their work in the necessarily limited space in which operations must be carried on, and its use will be continued by the Wm. Grace Co. in the erection of the superstructure. The equipment consists of a portable track made in 15-ft. sections and about 40 steel double side-dump cars of 1-yd. capacity.



Site of the Cook County Courthouse in Chicago while Wells Were Being Sunk for Foundations.

Experiments With Tar and Oil for Roads at Jackson, Tenn.

During the last year the Office of Public Roads cooperated with Mr. Sam C. Lancaster, city engineer of Jackson, Tenn., and chief engineer of the Madison County Good Roads Commission, in making a series of careful experiments at Jackson, to determine the value of coal tar, crude Texas oil and several grades of its residue when applied to earth and macadam roads. The official report of this work has recently been made public by the Office, and the following notes are taken from it.

The macadam streets in the business center of the city were built originally of the hard siliceous rock known as novaculite. A year ago, after fifteen years of wear, repair of these streets became necessary. The old surface was first swept clean with a horse sweeper, so as to expose the solid pavement beneath. This was done because tar will not penetrate a road surface which is covered with dust and loose material. Next, the surface was loosened by spikes in the wheels of a 10-ton steam roller, the streets reshaped, and new material added where needed. The road was then sprinkled, rolled, bonded and finished to form a hard, compact, even surface, and allowed to dry thoroughly before either tar or oil was applied, for these substances cannot penetrate a moist road surface. The best results are obtained when the work is done in hot, dry weather, and accordingly the tar was first applied in August.

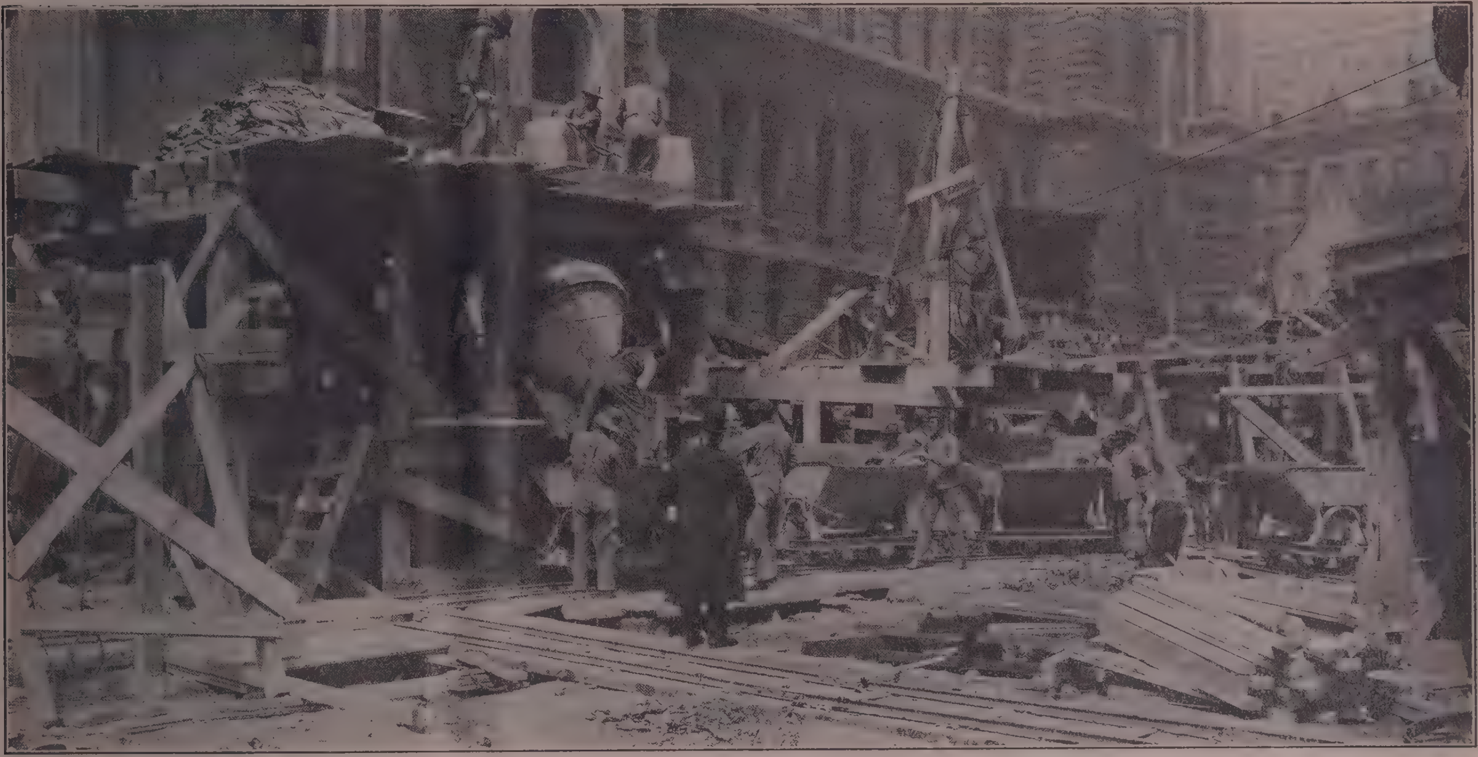
Other sections of streets and roads were built of new material entirely, but no tar or oil was put on them until after they had been subjected to traffic. Sections of country roads which had been built one to two years were also treated with tar and oil.

The tar used came from Ensley, Ala., and was a by-product from the manufacture of coke. It was practically free from moisture. A portable boiler was connected with the steam coils of the tank cars, in which it was delivered, to heat the tar and keep it hot, thus saving time in bringing it to the temperature desired for spreading on the road. It was then taken from the cars and poured into a tank wagon of 500 gal. capacity by means of a hand-lever pump. This portable tank had a small fire box under one end, with a flue running directly beneath the tank to a smokestack at the other end. A fire was kept in the fire box and the tar brought to a temperature which generally reached 210° F., but when placed on the road it was reduced to a temperature of 160° to 190° F. The hottest tar produced the best results. A horizontal pipe with an adjustable, longitudinal slot, attached to the rear of the wagon and extending down close to the surface of the road, was first used to spread the tar, but this became clogged and did not give an even flow. It was therefore abandoned, and in place of it a piece of four-ply 1¼-in. rubber hose was attached to the wagon. This hose had a nozzle of 1-in. pipe, slightly flattened at the end to produce a broad stream, and was provided with a valve for controlling the flow. The tar was spread with this hose over a radius of about 15 ft. of road surface.

Laborers, with street cleaners' brooms of bamboo fiber, followed the tank and swept the surplus tar ahead. They spread it as evenly and quickly as possible, and in a layer only thick enough to cover the surface. One side of the street was finished at a time, and barricades placed to keep off the traffic until the tar had had time to soak into the surface. Under a hot sun, with the road surface thoroughly compact, clean and dry, and with the tar heated almost to the boiling point and applied as described above, the road will absorb practically all of it in eight or ten hours. A light coat of clean sand, screenings, or the clean particles swept from the surface of the road, may then be spread as evenly as possible and rolled in with a steam roller. These different top layers were applied to various sections, and in one case the road was left to dry without spreading anything except the hot tar. In another instance sand was applied to the tar within two hours, which resulted in the absorption of the tar by the sand and lessened its penetration of the road surface. It was necessary to remove this sand-tar mixture, which peeled up under traffic. A sufficient amount of tar, however, had penetrated the surface of the road to make it waterproof, and after more than seven months of service this section of street is in good condition.

In spreading the coat of material for drying the surface of the road and absorbing the surplus tar, only enough should be used to cover it lightly, as after rolling this surplus material will be washed or blown away, or it may be removed with street sweepers and the surface left smooth and clean.

Table I gives the cost of labor in preparing the road and applying the tar in five different experiments. No account of lost time was kept. Negro labor was used, at $1.25 for a ten-hour day, and $3 per day was paid for teams. The quantity of tar per square yard was computed from the number of gallons used on the areas covered in the different sections and varied slightly. The average quantity was 0.45 gal. Little difference resulted in the appearance of the various sections. The tar was spread with the slotted pipe in the first two experiments and with the hose in the last three. Sand was used for a top layer in the second, fourth and fifth experiments, while sand and clean sweeping were used for this layer in the first and limestone screenings in the third.



Concrete Mixing Plant and Railway System for Handling Concrete and Spoil from the Wells.

Rolling was done at odd times and no exact cost can be given of this item in the last three experiments. The average cost per gallon of filling the tank, heating the tar, and hauling it to the road was $0.0024. To obtain an approximate total cost per square yard of this work, add the cost of 0.45 gal. of tar, which was the average quantity applied per square yard, to the cost of labor per square yard.

After more than seven months, including the winter season of 1905-6, the tarred streets and roads are still in excellent condition. They are hard, smooth, and resemble asphalt, except that they show a more gritty surface. The tar forms a part of the surface proper and is in perfect bond with the macadam. Sections cut from the streets show that the tar has penetrated from 1 to 2 in., and the fine black lines seen in the interstices between the individual stones show that the mechanical bond has been reinforced by the penetration of the tar. The tar is a matrix into which the stones of the surface are set, forming a conglomerate or concrete. A second coating applied a year after the first would require much less tar than the first, as the interstices of the rock would then be filled with tar.

A tarred street is dustless in the same sense that an asphalt street is dustless, though a fine sandy powder wears off as in the case of asphalt. It can be swept or washed clean. These streets have since been swept regularly and the city government is in favor of treating all of the streets with tar. The cleaning that would soon ruin an ordinary macadam road does not injure the tarred surface, as the stones are not torn up or disturbed. The tar itself has antiseptic properties, hence its use would be beneficial both as a germicide and as a means of securing cleanliness.

TABLE I.—COST OF LABOR PER SQUARE YARD IN FIVE DIFFERENT EXPERIMENTS.

Area covered. *Square yards.*	Tar per sq. yd. *Gallons.*	Sweeping	Hauling and heating tar.	Applying tar.	Applying sand.	Rolling.	Total.
972	0.43	$0.0012	$0.0011	$0.0025	$0.0028	$0.0006	$0.0082
1,455	.34	.0012	.0009	.003	.0027	.0006	.0085
4,720	.42	.0017	.0013	.0028	.0037	.....	.0095
4,658	.53	.0012	.0012	.003	.0029	.....	.0083
1,440	.40	.0018	.0005	.0014	.0019	.....	.0056

On one section of country road a coating of light crude Texas oil was first applied, and after this had penetrated, a coat of hot tar was spread over the surface. After allowing this to dry for eighteen hours, a coating of sand was spread over the tar. This has given fairly good results, but was no improvement over the tar spread on the dry road, as the oil seems to have prevented the penetration of the tar to some extent.

On some of the city streets the unbound stone between the rails on the street-car tracks was covered with tar, and this has resulted in a hard waterproof surface from rail to rail. Previously the stones were loose and troublesome from lack of traffic, and heavy rains washed the track out badly on the steep hillsides.

Experiments with Oils.—Seven tank cars of oil, given by some Texas and Louisiana companies, were used at Jackson. It varied in quality from a light, crude oil to a heavy, viscous residue from the refineries. Over 7 miles of country road and several city streets were treated.

At first, some of the lighter crude oils were applied with the same tank wagon that was used for the tar. Hose and brooms were used to spread the oil, and practically the same process was followed as with the tar. The oil soaked into the macadam very quickly and left no coating on top. It caused the light covering of sand which was applied to pack down and gave the road a dark color.

It was soon noticed that the preliminary sweeping was unnecessary, as the roads were practically free from dust and oil would penetrate the surface. The removal of detritus was a loss to the road, which had to be replaced by sand to prevent excessive wear on the stone. It was later found that it was much cheaper to use an ordinary street sprinkler than the tank wagon, and in this case spreading the oil with brooms was unnecessary.

The crude oil was used cold, and the cost of applying it with the different methods used is given below. On a city street 8,266 sq. yd. were treated at the rate of 0.48 gal. of oil per square yard with the use of the tank wagon and hose. The cost of labor per square yard was as follows: Sweeping street, $0.0011; filling tank and hauling, $0.0008; oiling street, $0.0024; spreading sand, $0.0014; total, $0.0057.

On a country road 2,000 gal. were spread, covering 5,206 sq. yd., at a rate of 0.38 gal. per square yard. The average haul was 1 mile. Only the manure was removed before oiling. The cost of labor averaged $0.0033 per square yard.

It took 9 men thirty minutes to spread 500 gal., or one tank load, and the 18-ft. road was covered at the rate of 1,860 ft. per hour. It took twenty-eight minutes to fill the tank car with oil.

With an ordinary street sprinkler, one man and team spread one load of 600 gal. of oil in fifteen minutes. The sprinkler thus spread 600 gal. in one-half the time that it took 9 men, with the tank wagon, to spread 500 gal.

The heavy residual oils were so thick when cold that they would not run through a 2-in. fire hose attached to the rear of the tank wagon, and it was necessary to pump the oil upon the road. The pump with which the tank was charged was used for this operation. Only 500 gal. of the heavy oil was applied cold. It formed a thick, sticky mass on the top of the road that rolled about under pressure and seemed to have an unlimited capacity for absorbing the sand which was spread upon it. The street had to be cleared of the greater part of this mass of oil and sand within a short time.

After this experience the oil was heated in the car by steam, and better results followed. It still ran slowly through the hose and nozzle, and it was found cheaper to take off the hose and allow the oil to flow from the outlet of the tank directly upon the road, where the men swept it over the surface with brooms. An air pump was tried, to increase the flow of the tank by pressure, but the tank was not tight enough to prevent the escape of air, and this experiment was unsuccessful.

Twenty-four hours after the application of the residual oil it was covered with sand or limestone screenings, and in four days it was firm enough to bear traffic without showing any wheel tracks. It shed the water well in a violent rain storm.

The following was the cost per square yard for putting residual oil on city streets with the use of the tank wagon. Approximately 0.71 gal. of oil was used per square yard: Sweeping street, $0.0010; heating, loading and hauling, .0017; oiling street, .0029; spreading sand, .0022; total, .0078.

Excellent results can be secured by the use of this heavy residual oil if it can be applied to the surface of the road at a temperature approaching the boiling point.

The medium grade of oil, which was tried next, is classed by the refiners as "steamer oil." It was heavy enough to leave a slight coating on the surface, which made a very compact covering with the dust of the road. Only the heavy matter was removed from the surface of the road before applying the oil. It was heated by steam in the car, but was not hot when it reached the road. It was not safe to build a fire in the tank wagon, and the best road surface was obtained where the oil was at the highest temperature. Some method of heating the oil safely on the road would greatly improve the results. This could be accomplished with a steam traction engine having steam coils connected with the tank, the engine hauling and heating the tank while spreading the oil. Most of this oil was applied with the street sprinkler, and it sprayed readily when hot.

In applying the greater part of the oil on the country roads the following men and equipment were used: A foreman at $2 per day; 6 laborers at $1.25 per day for working on the road and pumping oil at the car; 1 tank wagon and 1 street sprinkler at $3 each per day; 2 firemen at $1.50 per day, and 1 ton of coal. This force spread in one day 3,300 gal.

No sweeping was done on the country roads except to remove manure and to spread the oil where it was inclined to puddle. No sand or other material was applied to the road after oiling.

More than seven months have now elapsed since the work was done. The light crude oil has produced little if any permanent results. The roads where it was applied are but slightly changed, and some dust arises on them from traffic. The only apparent result is a slightly darker color on the shoulders of the road, and but little difference can be noticed between this and other sections of the road which were not treated. This oil was too volatile for the purpose, and where it has to be shipped for any distance does not justify the expense of using it.

The medium steamer oil from Texas has given good results. There is a thin surface coat of dust packed down that protects the stone from the grind and pounding of traffic. This effect is very noticeable in driving over it. The harsh grinding noise of the wheels, which is pronounced on the novaculite surface, disappears at once, and there is decided relief in driving upon it. It is practically noiseless. This coating is perhaps one-eighth of an inch thick, and is not a concrete, but compacted dust, which is made to cohere by the oil with which it is saturated. This road does not wash or pick up, and the wear on the rock is much decreased.

A good macadam road forms a wearing coat of fine material, which is necessary to its existence. If this coat is removed, another is formed and the life of the road is gauged by the rapidity with which the detritus is removed from the surface. The more rapidly it is removed the shorter will be the life of the road. The important result of applying the "steamer oil" was that the wearing coat was fixed and held to the surface, consequently the life of the road will be much greater. Of course some of it has blown and washed away, but it is perhaps safe to say that the loss is decreased by at least 75 per cent.

The best results were obtained with the heavier oils when the oil was hot. The road treated with the heaviest oil is entirely dustless. Teams passing from the bare macadam upon the oiled road show this, for the cloud of dust behind a wagon disappears at once, and the oiled roads can be cleaned or swept as well as the tarred roads. There is but little noise even from the horses' hoofs.

Another experiment was tried of treating an ordinary earth road with the heavy oil after it had been shaped and graded. The soil was composed largely of sand and the oil was harrowed into it and the road rolled. This piece of road has become fairly smooth and firm enough to bear traffic. It is not hard like macadam and has small wheel marks. It is about as good as the usual earth road where the soil packs well in fair weather. It is an improvement on the old road, as the sandy soil was cut into ruts, but it can hardly be recommended for use where the oil has to be shipped a great distance and is high in price.

AN IMPROVED FORM OF SUPERHEATER has been devised by G. L. Sanberg in Moscow, Russia, which is intended to effect more efficient distribution of the superheat to the saturated steam. Owing to a conviction that the efficiency of superheating depends not so much on mere area of superheating surface as on the form and section of that surface, he has used an internally ribbed tube with an arrangement of superheater connections and construction by means of which the furnace gases are passed around the outside and the saturated steam in two passes through the ribbed projections. Owing to the requirements of locomotive operation the apparatus is arranged to be by-passed when steam is not being used. It is found that each square unit of superheating surface in the ribbed section is equivalent to one and one-half times the same surface of a similar round section, as to efficiency of superheating. Apparatus occupying the same space as the present form of locomotive superheaters now very generally in use, is found to be 103 per cent. more efficient.

The Foundation of the Myers Building, Albany.

The John G. Myers Co. department store, Albany, N. Y., occupied buildings covering a lot about 212 ft. deep with fronts of about 58 ft. on Pearl St. and 70 ft. on James St. The construction was very irregular on account of the successive enlargements of the store by adding to it old buildings, most of them originally designed for dwelling houses. These were connected and altered so as to form parts of the general store, but repairs were made without uniformity and the original building was being remodeled when, in August last, it collapsed as described in The Engineering Record of September 2, 1905. This accident was directly due to the undermining of old column piers by the excavation which was being carried on under the floor of the building. This caused a portion of the old structure to fall, and called attention to the condition of the remainder, so that it was decided to tear down the entire building and replace it by a six and eight-story steel-cage structure occupying the entire site.

When the old building was removed it was apparent that some of the adjacent buildings were also very old, and in some cases weak and in poor condition. Some of them consisted of several stories built at different periods, and some of them did not have independent party walls and required their adjacent sides to be temporarily closed and floors supported when the store building was removed. It was at first intended to build the thirty-seven foundations for the column piers in excavations made to rock in open caissons or cofferdams. Excavation was commenced in sheet pile cofferdams and was carried through a stratum of dry yellow clay, another of blue brick clay and into a layer of very wet soft clay overlying about 7 ft. of hardpan on top of the hard blue shale rock about 20 ft. below the river water level. The wet clay was almost of the consistency of quicksand and the first excavation was made through it with great difficulty. When it was encountered in the second cofferdam the unbalanced pressure became so great that it forced the bottom material up rapidly, the men had difficulty in escaping, and the excavation was quickly filled to a depth of 9 ft. This demonstration was so conclusive that it was determined to abandon the open excavation process and to build the foundation piers with pneumatic caissons. The contract for this work was awarded to The Foundation Co., of New York, who commenced operations in January, 1906, and completed them in March, thus finishing a large amount of difficult work in almost exactly two months.

The original surface of the ground sloped down about 20 ft. from Pearl to James St., and neither the old buildings on the store property nor those adjacent to it had cellars excavated more than a few feet below the surface. Most of them had no cellars at all. The walls were of brick with narrow footings resting on the yellow clay, generally not more than 4 or 5 ft. below the surface. The original moisture in this clay having been greatly decreased by drainage, the clay had dried so as to cause considerable settlement in the buildings. The old brickwork consisted chiefly of thin walls, some of them much more than one hundred years old, laid in lime mortar, and as they were generally weak and cracked in many places it was necessary to provide very careful and complete supports for them before disturbing the ground near or under their footings.

The first work of The Foundation Co. was, therefore, to provide bracing or underpinning for about 400 lin. ft. of walls from one to four stories high on both sides of the lot. The Whitney Building extends through from Pearl to James Sts., bounding the whole of the north side of the lot. It is of irregular height, varying from one to five stories and basement. The five-story portion fronting on Pearl St. had a good brick party wall, which carried the ends of steel floor girders and had a 24x30-in. concrete footing about 11 ft. below the highest part of the ground surface, and approximately at the level of the excavation for the new cellar floor. The remainder of the Whitney Building did not have a separate party wall except for a length of about 70 ft. in the basement where there was a brick wall 8 in. thick.

The adjacent side had been temporarily enclosed with ⅞-in. tongue and groove siding and tar paper nailed to the original 2x6-in. studding 16 in. apart. On the James St. front, the building was three stories high above the basement and the upper story was strengthened by means of horizontal 1½-in. tie rods about 20 ft. apart. These rods had screw ends with nuts engaging washers and side bearing pieces on the outsides of the front and rear walls and were adjusted by turnbuckles operated to put the rods in moderate tension against the ends of the adjacent parallel floor joists.

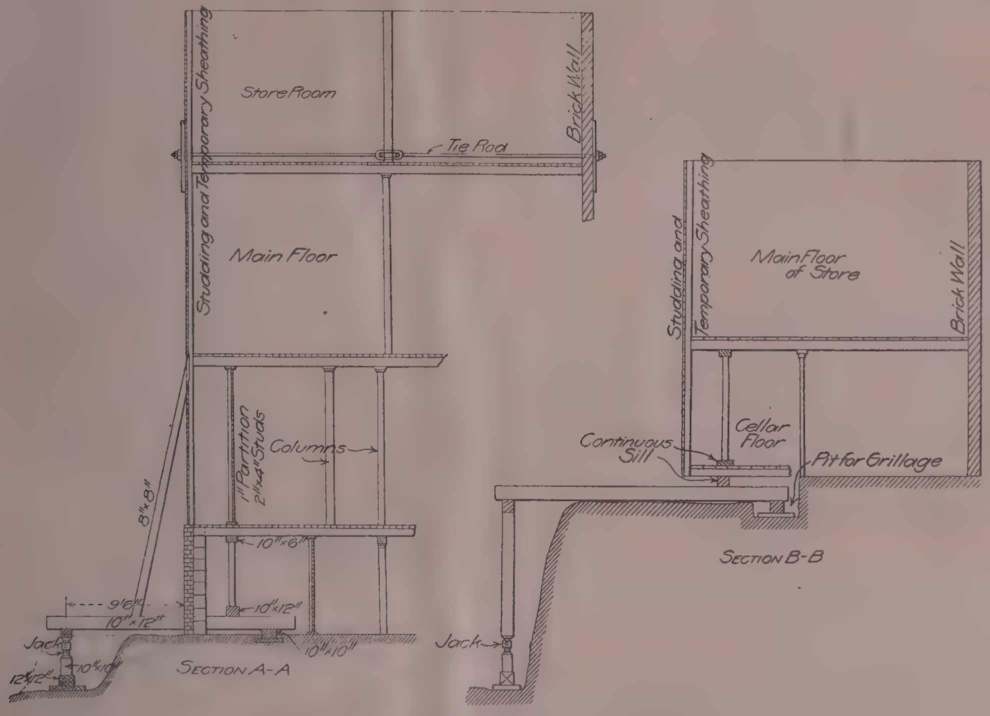
The face of the building was braced at the second or main floor level with 8x8-in. inclined shores, spaced 11 ft. apart on centers. The lower ends of these shores rested on 10x12-in. needle-beams that also carried the basement brick wall. A line of longitudinal timbers parallel to the brick wall rested on the upper sides of the needle-beams and supported vertical shores carrying a corresponding longitudinal cap receiving the first-floor beams and transferring their loads from the brick wall directly to the needle-beams. In the vertical plane of these shores in the second story about 3 ft. clear of the temporary side wall there was built a partition with 2x4-in. studs 12 in. apart, sheathed with 1-in. tongue and grooved boards. This partition had bearings on the floor-beams above and below it through longitudinal 3x6-in. planks and thus afforded a considerable support to the ends of the main floor-beams.

The needle-beams engaged the basement wall close to its foot and were supported inside the Whitney Building on longitudinal timbers distributing the load over the ground at a clear distance of about 6 ft. from the face of the wall and far enough from it not to be endangered by the excavation at its exterior face. The opposite ends of the needle-beams about 21 ft. long were carried on a line of 10x12-in. longitudinal beams parallel with the wall. These beams were supported on pairs of vertical shores at each needle-beam. The lower ends of the shores rested on a 12x12-in. longitudinal sill piece with transverse grillage planks 3 ft. long, laid under it in a trench carried down to subgrade before the underpinning was commenced.

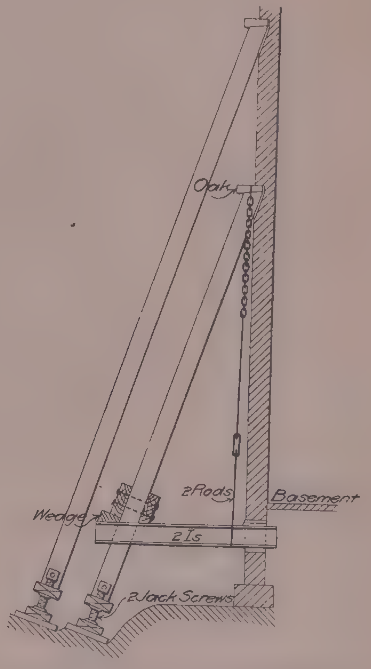
Between each pair of vertical shores there were placed jack screws by which the upper longitudinal timber was raised so as to transfer the full weight of the wall to the needle-beams. As fast as the jack screws were operated, the bearings between the vertical shores and the longitudinal timbers were adjusted by pairs of wedges driven to follow up the screws and take the load from them to the verticals. Afterward the excavation was completed to subgrade in the Myers Building, and to the same level for a short distance inside the wall of the Whitney Building, and the new footing was built for the latter, and the loads transferred to it in the usual manner.

The one-story and basement portion of the Whitney Building had a wooden party wall seated near the edge of the bank with a 24x24-in. rubble footing on the yellow clay at a level about 15 ft. above subgrade of the Myers Building. It was necessary to support this building and permit the excavation of the clay which had been left, forming a berm about 10 ft. wide around the face of the building. In order to obstruct the basement as little as possible, a trench was tunneled to a depth of about 3 ft. below the floor of the Whitney Building parallel to and 8 ft. distant from the wall. In it a line of 12x12-in. timbers in overlapping lengths was laid on 3-ft. grillage planks.

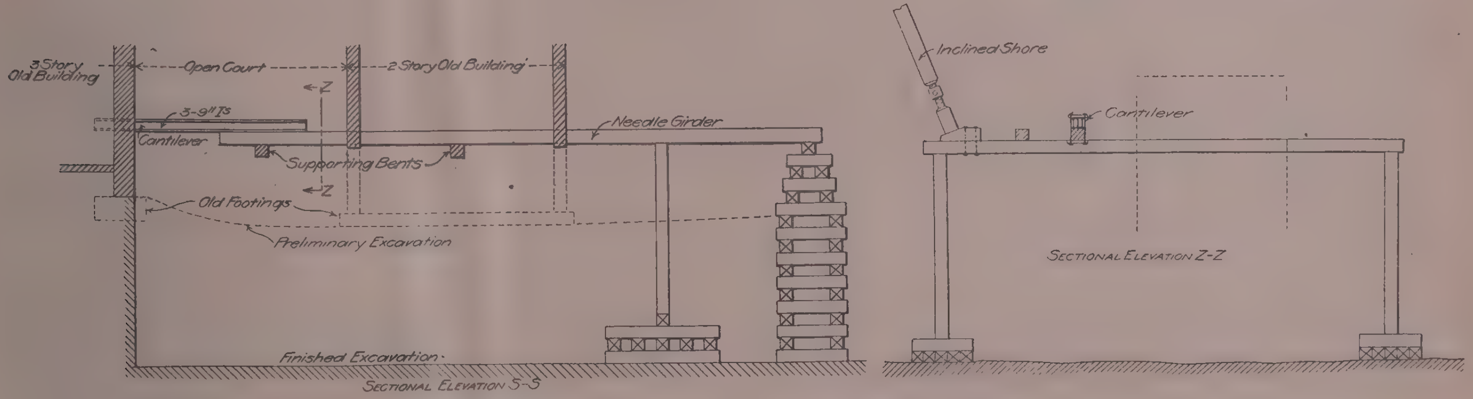
Small drifts from 10 to 14 ft. apart were excavated just under the floor transverse to the side wall, and in them 12x12-in. horizontal beams about 25 ft. long were inserted to take bearing at their extremities on the longitudinal timber in the trench. The outer ends of these beams were carried on vertical shores clearing the face of the bank to be excavated and seated on longi-



Needlebeams Under Whitney Building.



Double Pushers and Needlebeam.



Combination of Needlebeams, Girders and Cantilever.

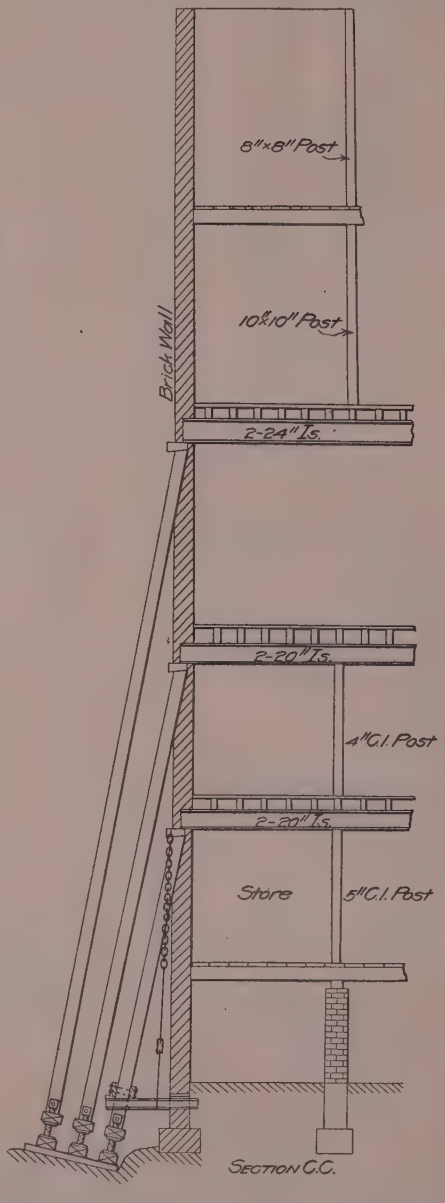
tudinal sills at subgrade of the excavation for the Myers Building. Just inside the wall a longitudinal timber was worked in between the transverse timbers and the parallel floor joists, and in its plane a set of vertical shores with top and bottom sills was arranged to carry the outer ends of the second-floor girders. With this arrangement it was possible to transfer the weight of the wall and some of the floor load to the transverse beams by operating jack screws at the lower ends of the vertical shores in the excavation. As fast as the bearing was thus secured the jack screws were followed up by wedging, which permanently carried the loads and allowed the clay bank to be excavated up to and underneath the wall of the Whitney Building so that the latter could be underpinned in the usual way with a new wall carried down to subgrade and serving both as a foundation and as a retaining wall.

In the five-story portion of the Whitney Building the footings of the brick wall were about at the level of the existing excavation and above subgrade of the final excavation. It was therefore necessary to support the full weight of the wall until the excavation could be completed and a new footing built. The wall was first braced by three sets of inclined shores or pushers, made with single 12x12-in. timbers battered about 1:6 and having their upper ends beveled horizontal and gained into the brickwork to take bearing directly against the lower flanges of the steel floor girders. The feet of the pushers were cut square and were seated on transverse 8x12-in. timbers 3 ft. long. On each side of the pusher a cast-iron thimble was inserted in the timber and took bearing against it through a flange on its lower end. This thimble was threaded to engage ordinary 4-in. jack screws with bearings on a parallel foot block seated on a cribwork carefully placed on a bed excavated at right angles to the battered pusher. The jack screws were operated to carry a large part of the weight of the wall and upper floors. Holes were cut through the lower part of the wall and horizontal divergent pairs of I-beams were inserted in them, connected to the first pusher to form figure 4 cantilever supports which carried the basement wall and provided for its support until the necessary excavation was made and the new footing built in it.

The Mann & Anker Building on the south side of the Myers Building fronts on Pearl St. and has a depth of about 108 ft. It is really composed of four separate buildings respectively 46 ft., 22 ft., 8 ft. and 32 ft. in depth, counting from Pearl St. The first, which is at least 150 years old, was originally a two-story brick building with a gable end on Pearl St. It was afterward converted successively into a three-story and a four-story building by the extension of the walls built on the sloping gable without efficient bonding. The next building, also four stories high, had been built up from a two-story building about 100 years old, the next was three stories high above the cellar and was about 75 years old.

The interior walls and floors of these buildings have been from time to time removed or changed so that little strength or rigidity remained in the structure. Some cast-iron girders and 15-in. I-beams had been inserted and were supported on thin brick pilasters until after the accident of last August, when they were reinforced by adjacent vertical I-beam columns bolted through the pilasters. All four parts of this building had wall footings several feet above subgrade, and as it was not possible to secure access to the interior of the building for underpinning them, the party wall was supported entirely from the outside by pairs of cantilever needle-beams of the figure 4 type.

The conditions varied so much that the spacing of these supports was irregular; generally, however, they were spaced about 10 ft. apart on centers, but were set at variable heights usually corresponding with the levels of the wall footings. A 12x12-in. pusher with jack screws at the bottom, as described for the Whitney Building, was first set to bear at the upper end against the second-floor joists. On the projecting horizontal surface of the upper end of the pusher an oak saddle or washer was wedged and received the bight of a 1-in. chain, the lower ends of which engaged the rings of 1½-in. vertical rods having forged stirrups at the lower end and turnbuckle adjustments in the middle. Fifteen-inch I-beams were seated in the stirrups, which acted as fulcrums, and were inserted in holes cut through the footing of the wall. A beam about 10 ft. long was thus suspended on each side of the pusher. The outer end of the beam reacted against 4x10-in. oak cross pieces bolted to the pusher. The beams were not placed quite parallel to each other, but were made to diverge toward the wall so as to support it at points about 3 to 5 ft. apart and thus reduce the distance between needle-beams.



Triple Pushers and Figure 4 Needlebeam.

The walls of the two, three and four-story buildings at the James St. end of the lot were also supported in the same way from the outside, and some of the partition walls transverse to the lot line were supported at the outer ends by cantilever needles made with horizontal steel or wooden beams supported at cellar-floor level on a fulcrum near the wall and counterweighted at the opposite end by a pile of pig iron.

One corner of the Mann & Anker Building was so near pier 28 that transverse needle-beams to support it would not clear the caisson, and it was, therefore, carried by a cantilever parallel to the long wall of the building and crossing an open court. This cantilever was made with three 9-in. I-beams clamped to a parallel 12x12-in. longitudinal timber that served as a sill supporting the full length of the side wall of a two-story building 150 years old opposite piers 29 and 30. This longitudinal beam was supported at the ends and intermediately on transverse beams arranged to clear the caissons, and the load it received from the two-story building served to counterbalance the reaction from the corner of the other building.

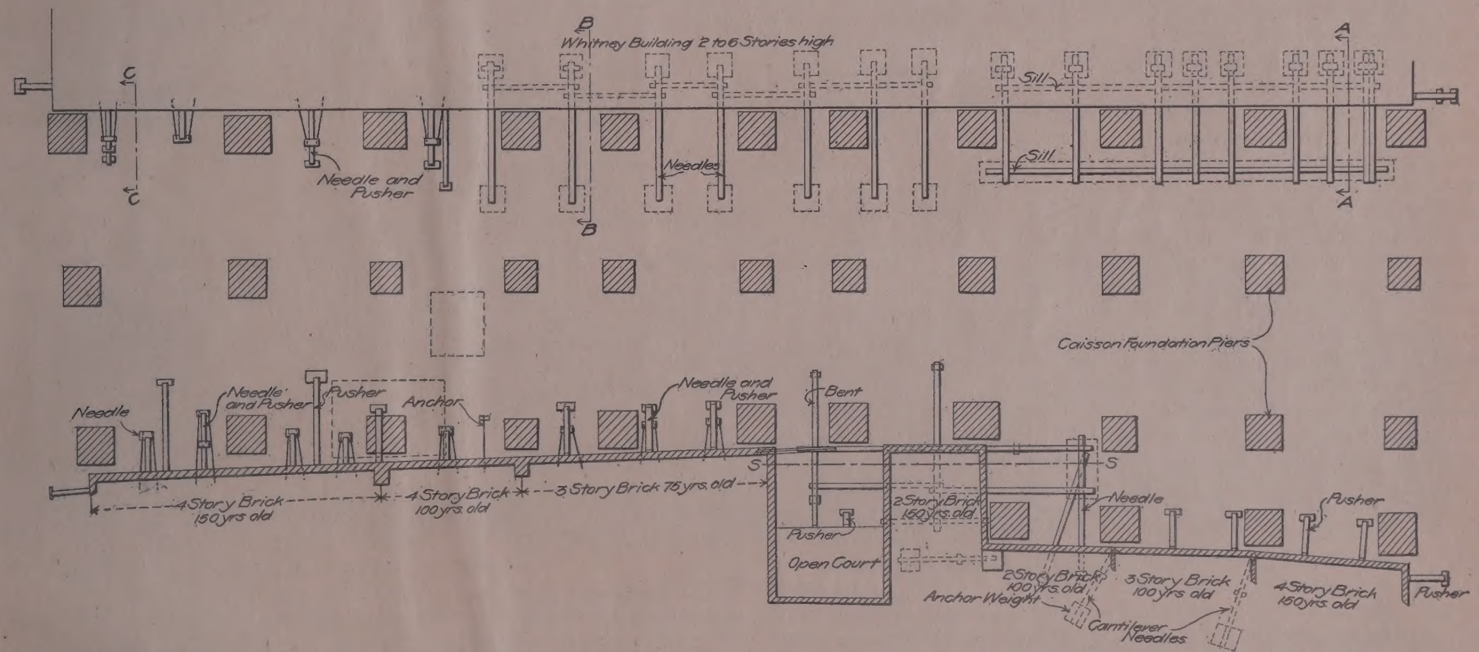
The two-story building here referred to was little more than 20 ft. long, and was located with three corners adjacent to caissons for the new piers. As it was an old structure of small value it was much more desirable to tear it down and, if necessary, rebuild it; but as the two stories were occupied by two tenants, one from Pearl St. and the other from Maiden Lane, this arrangement could not be made, and it was necessary to maintain it uninjured and underpin its walls. The building was, therefore, supported on a system of needle-beams and cantilever passing through it from side to side as indicated in the general plan.

In this locality the winters are likely to be severe, with heavy falls of snow, and in order to continue the work uninterruptedly during the cold weather it was provided that the site should be covered by a temporary roof and that the enclosure should be heated. After the site was cleared of debris, vertical posts were accordingly set up in longitudinal and transverse rows and carried beams and joists for a board roof covered with tarred paper about 20 ft. above subgrade. The difference in elevation between Pearl and James Sts. made a 20-ft. step in the roof necessary, and it was built in two levels, one 20 ft. above Pearl St., breaking at column 15 to the level of the James St. roof. The ends of the lot were also enclosed with a wooden siding and large doors were provided through which materials, caissons, etc., could be delivered on trucks. A power plant consisting of three 80-h.-p. boilers was installed near nier 21, which had been sunk by open excavation, and furnished steam to operate two 80-h.-p. air compressors. They discharged through a cooler to a receiver from which the air was distributed to the caissons at about 20 to 30-lb. pressure. As many as six of the latter were under pressure at once and received air through 2-in. pipes with valves and pressure gauges at their connections with the main where an attendant was always stationed to regulate the supply and maintain a constant gauge reading.

The rectangular wooden caissons were of four sizes from 6 x 6 ft. to 6 x 7½ ft., and had a uniform clear height of 7 ft. inside. They were of ordinary simple construction with walls made with 8x12-in. planed timbers, except the top and bottom courses, which were 12 x 12 in. These were drift-bolted together and tied by 1¼-in. vertical through rods engaging the 6x6-in. angle that formed the cutting edge. The top and bottom courses were 12 x 12 in. and the roof was made of a single course of 6x6-in. timber. The walls and roof were not sheathed, but all joints were calked with spun oakum. The caissons were built complete by the contractor in a building rented for the purpose a half mile away and were delivered by trucks to the site, where they were unloaded and set in position by four stiff-leg derricks with 30-ft. booms of 10-ton capacity, each operated by a Lidgerwood hoisting engine.

The derricks were seated on the roof and were supported by towers arranged in the excavation so as to clear the sides of the piers. The ends of the stiff legs and the derrick sills were supported on vertical shores and anchored by wire cables to timber platforms laid on the bottom of the excavation and heavily loaded with pig-iron. The caissons were lifted from the trucks, swung over the roof and lowered through temporary holes cut in it as required. Each caisson had a single steel air shaft 45 in. in diameter in 10-ft. lengths. This shaft was provided with two ladders arranged with the side pieces projecting at right angles to each other to form guides for the bucket so that the latter could not swing out of line and materials could be hoisted or lowered while men used the ladders and were protected by them from the bucket. The cofferdam was made in sections, with 3-in. vertical pine boards permanently attached to the caisson, and the space between the cofferdam and shaft was filled solid with concrete. The shafts were surmounted by Moran air locks with counterbalanced revolving doors. Timber platforms were built on the upper edges of the cofferdams and loaded with a maximum of 75 tons of pig iron to sink the caissons.

The 36 caissons were all carried through hardpan from 7 to 8 ft. in thickness to a bearing on solid rock at a depth of 40 to 60 ft. below the bottom of the excavation. The surface of the rock was leveled and cleaned and the interior of the caisson was filled with hand mixed 1:3:5 concrete made with Helderberg Portland cement and deposited in bottom flap buckets. Sinking the first caisson was commenced Jan. 13, 1906, and the last one was finished March 19. Trowbridge & Livingstone, New York, are the architects of the building, and the Remington-Macomber Co., of New York and Boston, is the general contractor. The shoring and pneumatic caisson work was executed by The Foundation Co., Mr. Howard J. Cole, superintendent.


B
Whitney Building 2 to 6 Stories high
A
C
Sill
Sill
Needles
Needle and Pusher
C
B
A
Caisson Foundation Piers
Needle
Needle and Pusher
Pusher
Anchor
Needle and Pusher
Bent
S
S
4 Story Brick 150 yrs old
4 Story Brick 100 yrs. old
3 Story Brick 75 yrs. old
2 Story Brick 150 yrs old
Pusher
Open Court
Needle
Pusher
2 Story Brick 100 yrs. old
3 Story Brick 100 yrs old
4 Story Brick 150 yrs old
Pusher
Anchor Weight
Cantilever Needles

Plan of Myers Building Foundation Pier Caissons and of Pushers and Needlebeams.

THE RELATIVE HEATING VALUES OF CRUDE OIL and California coal have recently been determined by tests. It was found that one ton of coal is equivalent to 718 lb. of oil, so that, as the oil weighs 7.6 lb. per gal., the ton of coal is equaled by 2¼ bbls. of 42 gal. each. Locomotive coal, which is of the best grade, is equivalent to 3¼ bbls.

The Proximate Composition and Physical Structure of Trinidad Asphalt.

A paper read before the American Society for Testing Materials by Clifford Richardson.

The vast deposit of native bitumen, extending over an area of more than one hundred acres and to a depth of over 135 ft., obtained in the so-called pitch lake which occupies the basin of an old mud spring in the Island of Trinidad, has been known for some time to be extremely uniform in its proximate composition, consisting of a mixture or emulsion of bitumen, a thermal water, free carbon dioxide and hydrogen sulphide and mineral matter, with an undetermined residue which has been denoted "organic matter not bitumen." The composition of the "pitch," as taken freshly from the lake, according to the methods of analysis hitherto generally employed, has been stated to be as follows:

TABLE I.—AVERAGE OF 30 ANALYSES.

	Percentages.
Water and gas, loss on drying at 100 deg. Cent...	29.0
Bitumen soluble in cold carbon disulphide........	39.0
Mineral residue after ignition..................	25.2
Undetermined matter by difference, "organic matter not bitumen"	6.8
	100.0

Industrially the crude pitch is submitted to a process of so-called refining which consists of heating it to a temperature of not over 160 deg. Centigrade, for the purpose of driving off the water present and obtaining a dry and compact bitumen. In this process nothing is removed except matter volatile at this temperature, so that the product may be regarded merely as dried pitch. In this form it has the following average composition when examined in the same manner as the original material:

TABLE No. II.—AVERAGE OF 15 ANALYSES.

	Percentages.
Bitumen soluble in cold carbon disulphide....56.5	
Mineral residue after ignition................	36.5
Undetermined, by difference.................	7.0
	100.0

If the composition of the crude pitch is calculated to a water and gas free basis the bitumen, mineral and undetermined matter will be found to be present in the following proportions: Bitumen, 55 per cent.; mineral, 35.5 per cent.; undetermined, 9.5 per cent.; total, 100 per cent.

From the preceding data it appears that there is less undetermined matter in the refined asphalt than in the original pitch. It is evident, on reflection, that the figures obtained by the methods of analysis employed do not accurately represent the actual composition of the substance. The percentage of bitumen represents the amount soluble in cold carbon disulphide and may be too low. A hot solvent or a better one might remove more. There is reason to believe, since the mineral matter consists to a considerable extent of clay, that this, or even the other mineral matter, might absorb or adsorb bitumen in a way which would prevent its removal by solvents. The mineral residue after ignition may be too low, owing to the volitization of the water of hydration of the clay and of some of the more volatile inorganic matter such as the alkalies and the sulphuric acid in combination with the ferrous iron in the thermal water. All these errors would be cumulative in the undetermined matter by difference and thus make the percentage assigned to this material much too high, even if it is not found to consist entirely of much substances which are in no sense organic matter not bitumen.

With a view of determining with some certainty what the character of the substances are which go to make up that portion of the refined asphalt which has been heretofore regarded as "organic matter not bitumen" the following investigations have been carried out in the writer's laboratory.

Water and Gas.—If a weighed amount of crude Trinidad asphalt, immediately after being taken from the deposit, is ground to a fine powder and exposed to the air for 24 hr. it will lose about 29 per cent. of water and a small additional amount of further exposure in vacuo over sulphuric acid, this latter small amount being very probably water of crystallization of the salts which are present. The total loss averages 29 per cent., with but very small variation, in the fresh pitch taken several inches below the surface, although on exposure to the air for some time a very considerable proportion of this amount may be lost, as in the case of storage of the crude material.

At the same time with the water the gas which it contains in solution, consisting of a mixture of carbon dioxide and hydrogen sulphide, is lost. Its percentage must be extremely small by weight.

Having determined the average amount of water in the fresh pitch with some degree of accuracy it will be convenient to conduct the further investigation of the pitch on the dried or refined material.

Mineral Matter.—The residue of mineral matter obtained on the ignition of refined Trinidad asphalt in a muffle averages, as the result of fifteen determinations of representative samples, 36.5 per cent., corresponding to 25.9 per cent. in the original crude material, with extremes of 36 and 36.8 per cent. As this ignition has taken place at a temperature approaching 800 deg. Centigrade there is every reason to believe that considerable organic matter has been volatilized, as is often found to be the case in the preparation of the ash of vegetable material. In the latter case the addition of tricalcium phosphate prevents such loss, and it seemed that this mode of procedure might be applicable to the asphalt. When the latter was ignited in the presence of the phosphates residue greater by 2 per cent. was obtained, 38.5 per cent., and one which more correctly represents the percentage of anhydrous inorganic matter present in the asphalt, and showing that 2 per cent. is volatilized in the ordinary course of ignition, thus accounting for this amount of the "undertermined matter."

The mineral matter on examination is found by elutriation to consist to a large extent, 30 to 40 per cent., of clay and, of course, its water of hydration, which may be properly regarded as a part of the mineral matter originally present, is lost on ignition. If the residue after the extraction of the asphalt with solvents is heated to a temperature of 340 deg. Centigrade, it looses from 4 to 6 per cent., the determination at such a temperature, of course, not being one capable of being made with great accuracy. A certain amount of this loss is plainly due to the volatilization or destruction of bitumen held by the clay present, as shown by its condensation on the side of a glass tube in which the heating is conducted, but as this amount, as will appear later, cannot exceed 1 per cent., the loss due to the presence of water in the clay must reach at least 4.5 per cent. The total loss on ignition, of bitumen and water in the clay must, however, amount to about 5 per cent., and be included in the "undetermined matter." When this per cent. is added to the 2 per cent. of inorganic matter volatilized at 800 deg. Centigrade, the entire percentage of undetermined matter obtained by the usual method of analysis is accounted for, as it appears that Trinidad asphalt really contains practically no organic matter not bitumen.

In order to determine whether this assumption is correct analyses have been made of mixtures of an extremely pure bitumen, gilsonite, with clay and other fine inorganic materials, the mixture being prepared by melting the bitumen and stirring the clay or other mineral matter into it, the stirring being kept up during cooling, and the cold brittle mixture being then ground to a fine powder in order to obtain a uniform material for analysis. The results of an examination of such mixtures by the routine methods are as follows:

Table III.—Analyses of Mixtures of Pure Bitumen with Various Materials.

	Bitumen, soluble in carbon di-sulphide. Per cent.	Mineral residue on ignition. Per cent.	Undetermined. Per cent.
Fullers earth—air dried	62.3	28.8	8.9
Fullers earth, ignited	59.7	34.1	6.2
Brick clay, air dried	72.3	22.9	4.8
Brick clay, ignited	77.9	17.9	4.2
Portland cement, ignited	82.6	15.8	1.6
Trinidad mineral residue, ignited	64.4	34.3	1.3

It appears from the preceding results that all the artificial mixtures of bitumen and fine mineral matter apparently contain as the result of the analyses a certain amount of undetermined matter or organic matter not bitumen, although from the nature of these mixtures nothing of this kind can be present. The amount varies from 8.9 per cent., in the case of the unignited Fullers earth, to 1.3 per cent. for the ignited mineral residue of Trinidad asphalt. The larger percentage is due to the presence of water of hydration in the Fullers earth, while the smaller percentage shows that the mineral matter in Trinidad refined asphalt is capable of retaining 1.3 per cent. of bitumen, either by absorption, adsorption, or both. Our assumptions in regard to the true composition of Trinidad asphalt are, therefore, correct and its actual composition should be stated as follows:

Table IV.—Actual Composition of Trinidad Asphalt.

	Crude Trinidad Asphalt. Per cent.	Refined Trinidad Asphalt. Per cent.
Water and gas	29.0	
Bitumen soluble in cold carbon disulphide	39.0	56.5
Bitumen retained by mineral matter	.3	.3
Mineral matter, on ignition with tricalcium phosphate	27.2	38.5
Water of hydration, clay and silicates	3.3	4.2
	98.8	99.5

In neither case is it possible for the occurrence of that percentage of "organic matter not bitumen" which has heretofore been attributed to Trinidad asphalt.

Bitumen.—In consequence of the preceding results it is of interest to study to some further extent the behavior of bitumen toward clay and other extremely finely divided inorganic particles.

Behavior of Bitumen with Clay and Finely Divided Mineral Matter.—It is well known that clay has the power of absorbing bases and dyes from their solutions and holding them so firmly that they cannot be entirely removed by solvents. The author here referred to the following articles regarding this subject: Cushman, Bulletin No. 92, Bureau of Chemistry; U. S. Department of Agriculture, page 16; Cameron & Bell, Bulletin No. 30, Bureau of Soils; U. S. Department of Agriculture, pages 52-61.

In this connection the behavior of solutions of bitumen toward clay and other fine mineral matter has been investigated. For this purpose a weighed amount of air dried white clay from Berkshire County, Massachusetts, was spread on the asbestos felt of a Gooch crucible and a 10 per cent. solution of an extremely pure bitumen, gilsonite, in purified carbon disulphide was poured upon it and allowed to remain in contact with it for 15 hr. The solution was then removed by suction and the clay was washed with the same solvent until the latter came through colorless. The same experiment was conducted with a brick clay from New Jersey, and with Fullers earth from Florida.

On drying the white clay and breaking it open it was found to be strongly colored by the absorbed bitumen which had not been removed by the solvent. The amount of bitumen retained by the different clays was found to be: White clay from Massachusetts, 1.28 to 1.03; brick clay from New Jersey, 1.24 to 1.38; Fullers earth from Florida, 8.94; all in percentages.

It is evident that the different clays have different capacities for absorbing bitumen, and it is not surprising to learn that Fullers earth retains the largest percentage, since the use of this material has been extremely successful for the purpose of clearing distillates of petroleum.

It seemed possible that an air-dried clay, owing to the hygroscopic presence of moisture which it might hold, might not absorb as much bitumen as one which has been dried at a temperature above the boiling point of water. In order to determine this the experiment was repeated with the brick clay from New Jersey after drying at 120 deg. Centigrade. The results obtained are as follows: Brick clay from New Jersey, 1.07 to 1.28 per cent. There is but a trifling difference in the amount of bitumen absorbed by the air dried clay and the dried clay.

In the same way it seemed possible that an ignited clay might not have as large powers of absorption as air-dried or dried clay. For the purpose of determining this ignited Fullers earth and the mineral residue from the ignition of refined Trinidad asphalt were subjected to the action of a bitumen solution and the amount of bitumen which was absorbed in each instance and could not be removed by solvents on continued washing was found to be: Fullers earth, 5.8 per cent.; mineral residue from Trinidad asphalt, .89 per cent.

The Fullers earth, it is found, does not present the same absorptive powers after ignition and it may, therefore, be assumed that the mineral residue from Trinidad asphalt, in the condition in which it exists originally in the crude or refined asphalt, would absorb more than nine-tenths of 1 per cent., which the ignited residue does.

It is evident, therefore, that the amount of bitumen extracted by a solvent from any mixture of that substance with a material containing clay does not represent all that is present in the mixture, and that in the course of an analysis made according to the customary methods that the amount of bitumen would be included in the percentage of undetermined material. The amount will, of course, depend upon the nature and proportion of the clay present.

With a view of determining the behavior of solutions of bitumens of various kinds toward clay, Fullers earth, ground limestone, silica dust and Portland cement, 90 per cent. or more of which pass a screen of 200 meshes to the lineal inch, when such solutions are passed through a column of these materials closely packed together in a glass tube, a number of experiments have been made. For this purpose glass tubes 2 c. m. in diameter and 150 c. m. long were filled for a distance of 50 c. m. with the mineral powder under experiment.

Carbon disulphide containing 0.1 per cent. gilsonite in solution is completely decolorized in passing through a column of Fullers earth, of the length mentioned. The solvent comes through quite pure. Eventually the solution becomes slightly colored and finally brown, but on evaporation of the first portion of the colored solution the residue is found to consist of bitumen in the form of malthenes or the softer hydrocarbons of gilsonite, showing that there has been a selective absorption, similar to that which has been observed in the case of passing crude petroleum through clay. A 2.5 per cent. solution treated in the same way comes through slightly colored from the beginning and soon contains the unchanged gilsonite.

After removing the Fullers earth from the tube and drying the same it is found to be colored a very deep brown and all of this color could not be washed from it by means of solvents. The action of Fullers earth on gilsonite is strongly absorptive and selective. With finely powdered limestone a similar result is obtained, but the amount of colorless solvent which passes is much less than in the case of Fullers earth.

In both the above cases absorption may be considered as the principal cause of the action of the fine mineral matter. In order to determine whether this was the sole cause tubes were filled with ground silica and with Portland cement, neither of which could possibly have any absorptive action. In neither of these cases did the solvent come through colorless at any time, but at first was a light straw color, quite different from that of the original solution which was jet black, and the bitumen in solution was of a soft nature. After removal of the mineral matter from the tubes it could be washed quite free from bitumen with the solvent showing that there had been no actual absorption. From this it must be assumed that adsorption plays a large part in the retention of bitumen by mineral matter.

Similar experiments were carried on using Trinidad refined asphalt instead of gilsonite. With this material the solutions were in every case colored, but contained in solution only the lighter hydrocarbons of the asphalt, and the fact that powders could not remove the bitumen entirely in the first portions passing is due to the presence of hydrocarbons of much lower molecular weight, as low as $C_{13} H_{26}$, in the asphalt than in the gilsonite.

The behavior of bitumen with these fine materials is of great interest from an industrial point of view as explaining the strong adhesion of bitumen to the mineral aggregate composing the major portion of an asphalt wearing surface.

Physical Structure of Trinidad Asphalt.—Having become acquainted with the proximate composition of the refined Trinidad asphalt it is of interest to study, and determine if possible, the manner in which the components have become combined in the crude asphalt and the reason for their existing in such very definite proportions in all parts of the deposit. The conclusion was originally drawn that the mixture of water, mineral matter and bitumen existed in the form of a mere emulsion, but the observation that when the crude asphalt was shaken with an excess of carbon disulphide no water rose to the surface showed at once that this was not the case, but that the water must be held by the clay and not in emulsion with the hydrocarbons. That this is so can be readily proved by shaking a paste of clay or fine sand and water with carbon disulphide when, as would be expected, the water does not rise to the surface of the carbon disulphide. A determination was then made of the amount of water which a residual clay such as is found in Trinidad asphalt would hold, either chemically combined, by adsorption, absorption, or in the voids between the particles.

When it was placed upon the felt of a Gooch crucible, moistened with water, and any excess allowed to pass off through the felt, the amount retained was found to be 136 per cent. of the original weight of the clay. When the water in the voids was removed as far as possible with a vacuum pump that retained amounted to 89 per cent. On placing the moist clay over sulphuric acid in vacuo very nearly the entire amount of water which was present in the clay was removed. At higher temperature about 5 per cent. of adsorbed water was lost, while on ignition 8 per cent. was found to be in combination, or perhaps partly adsorbed. It is evident that clay has a great capacity for water, and if we observe the relation between water and residual mineral matter in the crude Trinidad asphalt, 29 per cent. of water and 30.6 per cent. of mineral matter, it is readily seen that the amount of mineral matter present is quite capable of absorbing and holding the water present. That clay actually absorbs the water under these conditions is not unexpected since it is frequently used for the purpose of removing water from oils and clarifying them. We may assume, therefore, that the definite relations of water and residual mineral matter in the asphalt is due to some definite equilibrium between the two materials, depending upon the capacity of the mineral matter for water. The mixture of the two may be regarded as the mud of the original spring.

To account for the definite ratio of mud and bitumen found in the crude asphalt it does not seem out of place to assume that a similar physical equilibrium occurs. The mud must be able to take up and hold a definite amount of bitumen and no more. Although we cannot at present explain why the relations should always be about 60 per cent. of mud to 40 per cent. of bitumen.

Artificial mixtures have been made of clay, water and pure bitumen, in which these substances are present in the same relation as in the crude asphalt. If the water and clay are first mixed the bitumen can be readily combined with the mud, but if the bitumen and clay are first mixed and heated to the softening point of the bitumen a mixture cannot be made, as the clay absorbs the bitumen and prevents the entrance of water, although under the high temperatures and pressure which undoubtedly exist where the crude material is formed the conditions would be somewhat different. The preceding fact would appear to be in confirmation of the conclusion that the mud must have been formed first, the bitumen afterwards having been combined with it.

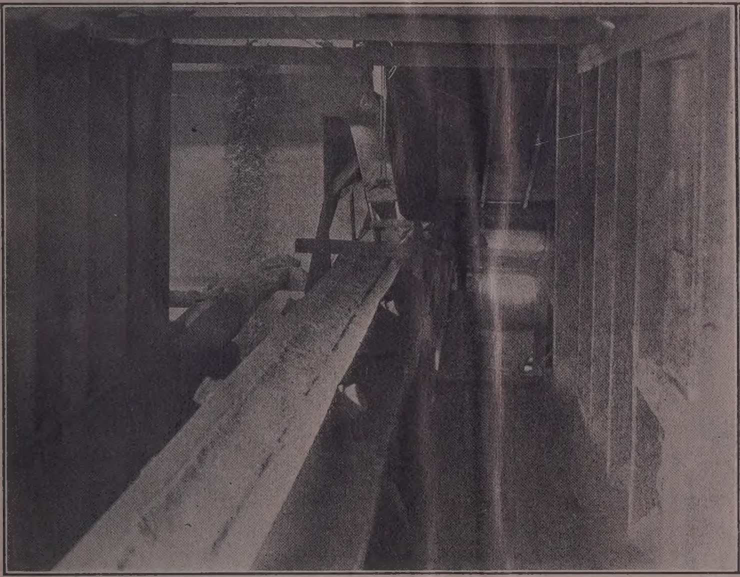
It is of interest to note that the artificial mixtures which have just been described lose their water as rapidly when exposed to the air as does the crude Trinidad asphalt, a mixture containing 29.5 per cent. having lost 29 per cent. in the course of 24 hr.

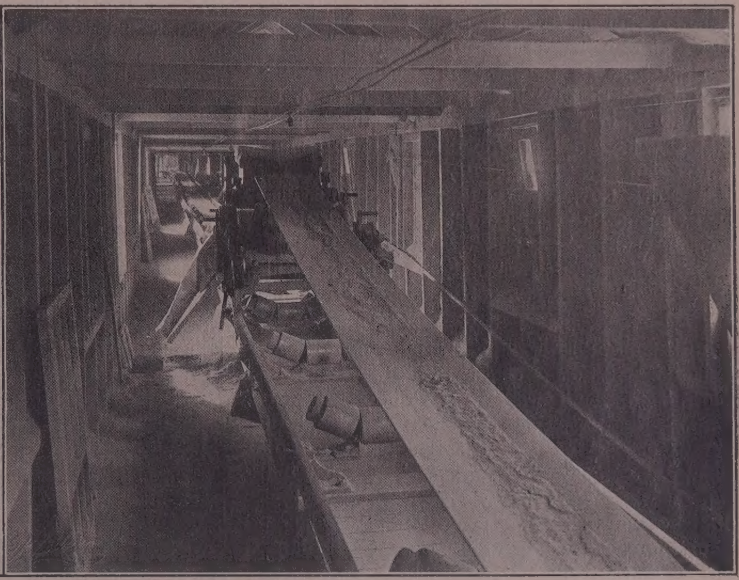
The preceding problem is an interesting one and is worthy of further investigation. It has been definitely settled from the results thus far obtained that Trinidad asphalt does not contain the amount of "organic matter not bitumen" that has been attributed to it and probably only a minute amount derived from grass or other vegetable growths.

Conveyors for Finished Cement at Marquette Cement Works.

The design of the conveying machinery for cement works has received much attention on account of the important part this equipment plays in such a mill. Formerly screw and bucket conveyors were used almost exclusively, but of late the belt type has been gaining favor steadily and is now employed for raw materials, clinker, finished cement and cement in bags. The accompanying illustrations show the leading features of a 16-in. belt conveyor 372-ft. long used at the plant of the Marquette Cement Mfg. Co. at La Salle to take the finished product from the mills to the storage room.

The material is delivered to the conveyor through a specially designed chute, which is so formed that the cement is discharged on the belt at the same speed that the latter is running. This not only keeps the chute from becoming choked but also prevents the cement from spilling over the sides. From the belt the material is discharged into the storage bins through openings in the floor of the monitor enclosing the conveyor. This operation is accomplished by means of an automatic self-reversing tripper, which can be held stationary above any one of the floor openings by throwing a clutch. This tripper is shown in one of the accompanying illustrations, which also gives an idea of the distance the cement is carried by the belt.


Receiving End of Cement Conveyor.


Tripper Device for Discharging Cement.

The belt is driven by a 15-h.-p. direct-current motor. The motor is belted to a pinion shaft, which drives the end shaft of the conveyor by spur gears. The conveyor runs at a speed of 350 ft. per minute and can carry each hour over 90 tons of finished cement. Both of the illustrations show an apparently insignificant feature of the installation which is, however, of vital importance to its effective working. This is the decking over the idlers on which the empty belt returns, which is thus protected from injury. This plant was furnished by the Robins Conveying Belt Co.

AN ELECTRICALLY-OPERATED BAGGAGE TRUCK has been built for experimental service by the Pennsylvania Railroad. It consists of an ordinary baggage truck with a storage-battery equipment, operated by twisting the guiding handle, and if the handle is dropped, the truck is stopped automatically. When the power is cut off the truck cannot be moved, the driving wheels being automatically locked by a magnet brake.

Letters to the Editor.

SUPERHEATED STEAM IN PUMPING ENGINES.

SIR: In July, 1905, you published a very able article by Mr. Nicholas S. Hill, Jr., on the selection of water-works pumping machinery. Very little discussion on these points has appeared in the engineering press from the standpoint of an impartial expert who is not interested in the design, or construction of any particular type of pumping machinery.

I think I may say that Mr. Hill appears to have handled the subject remarkably well, and I am very much in sympathy with the ideas which he has expressed. If there is one point which I think might be more amplified, I should perhaps refer to his brief mention of the advantages of using superheated steam in pumping engines. I became convinced of the special benefit of superheated steam in this class of machinery a long time before I was interested in, or knew anything about superheater construction. My interest was awakened by noticing the general use of superheated steam in English pumping stations, and I had an opportunity of actually running a series of very careful tests myself at a small pumping station at St. Albans, in England. These tests were published in The Engineering Record of 1899. The use of superheated steam clearly showed a very handsome fuel saving in this case and the plant throughout worked in a very satisfactory manner. More recently superheaters have been introduced quite extensively in pumping stations in the United States. They are to be found in the main pumping stations in Chicago, Ill., Brooklyn, N. Y., New York City, New Orleans, La., Louisville, Ky., Cincinnati, Ohio, Lowell, Mass., and Montreal, Canada. As reports from these stations become a matter of record the superheaters will no doubt give a very good account of themselves.

It is interesting to note that the first triple-expansion pumping engine which Henry R. Worthington built was of a vertical type for the water company at Port Perry, Pa. There were two styles of boilers in the station, one of which gave superheated steam and the other did not. It was always noticed that when the superheated steam boiler was in operation the engine would produce about 12 per cent. better duty, the superheat being 80 deg. The men on the job were considerably puzzled at first at this apparent discrepancy in their results, until they realized the fact that the difference could all be traced to the boilers which they were using.

A recent and notable instance of the success of superheated steam in improving the running conditions and duty of pumping engines will be found in the city of Lowell, Mass., where the effect of superheat is to be observed on a remodeled vertical flywheel engine and also on a high-duty, direct-acting and on a low-duty direct-acting engine. An examination of the records of the pumping station before and after the superheaters were installed, which was somewhat over a year ago, will show considerable increase in the amount of water pumped per pound of coal on all three types of engines, for no other reason than that the steam is superheated.

During the convention of the New England Water Works Association, at Boston, beginning July 10th, the members could readily visit the station at Lowell, which is only a short distance from Boston, and observe the effect of this improvement at that station.

Yours truly,
THE POWER SPECIALTY CO.,
E. H. FOSTER.

New York, June 22.

THE PLAIN REINFORCING ROD.

SIR: In the following the writer does not mean to prove that under all conditions, the plain reinforcing rod is as desirable as an equal weight of some mechanical bond type; neither does he intend to state that the mechanical bond type is in all places a necessity. Radical statements of this kind have frequently been made by advocates of one type of rod, both against the opposing type in general, and against the product of competitors manufacturing rods of a type similar to their own, in order thus to promote, as far as possible, the exclusive use of their particular type. Such utterances are always to be regretted, and have, in many cases, done much to prevent the opportunity of erecting any type whatever of reinforced concrete. They cause the general public to become needlessly distrustful of all such construction, thus inevitably reacting against those responsible for the statements.

As a matter of fact, concrete reinforced with plain rods in proper proportion, has been generally successful in all places where not subjected to violent shocks or to continued vibration. Such places are many. Where subjected to vibration and shock, plain reinforcing is successful, if used in what would generally be termed "excessive amount," in which case, the type best fitted for installation becomes merely a matter of dollars and cents. Pound for pound, the plain rod has the purely commercial advantages of cheapness and general availability at short notice. In the writer's opinion, if more careful attention had been paid to the tamping than is sometimes the case, the instances of failure reported would have been fewer. It has been stated that the bond of concrete to plain rod is due solely to the entrance of cement into microscopical pits in the surface of the rod.

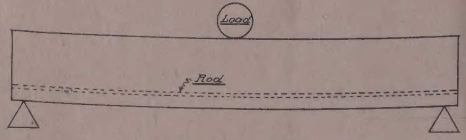


Fig. 1

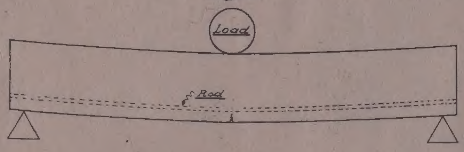


Fig. 2

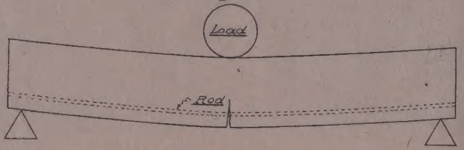


Fig. 3.

It is unquestionable that there is a definite chemical bond, if we may use the term, of concrete to steel, as many of us have found to our sorrow, when we used sheet iron bottoms to our forms and forgot to oil them.

It has been further stated that when the steel elongates (of course reducing in area) these microscopical pits become separated from the concrete and the bond is destroyed, and that when the bond is destroyed, the cracks in the tension member of the beam are likely to extend at once, up past the reinforcing. The first condition cannot occur under normal loading of a concrete beam of proper mixture. The latter part of the statement is true, but as regards comparatively quiescent loads, is viewed from the wrong standpoint. What is equally true is, that provided the beam is not being subjected to sudden shock or vibration, the concrete to steel bond cannot become broken until a crack has extended up past the reinforcing rod, which is simply another way of saying that the unit elongation of steel and concrete are the same, but the modulus of fracture is different. To illustrate, Fig. 1 shows a diagram of a concrete beam reinforced with a plain rod and under a normal quiescent load. The unit elongation of a 1:2:4 concrete when reinforced and steel are both the same so both steel and concrete have elongated alike. Both substances are isotropic, the Poisson's ratio being about ¼ for each, from which the reduction of areas is the same and the bond is intact. Fig. 2 shows the same beam under a quiescent load greater than can be withstood by the concrete at the extreme bottom of the beam. A small crack has started at this point, but the load is insufficient to have produced such elongation as would be necessary to cause the crack to extend up to the reinforcing rod. Hence, as before, concrete and steel have elongated alike; the reduction of areas are the same and the bond is still intact. Fig. 3 shows the same beam under greatly excessive load. The steel has elongated more than can be withstood without fracture by the concrete at the reinforcing line. The crack has extended up past the rod and the bond is broken as far back as this excess elongation has taken place.

From the foregoing discussion, it is evident that the tests made by Professors Constant, Spofford and others, of the holding power of various types of rods in concrete, while they show a unit stress in either plain or mechanical bond rods greater than would be allowable on steel by the building laws of any state, are still not quite fair to the plain rod. In the case of each of these tests, the concrete was mechanically held in place on end, and the rod pulled from it. The concrete was therefore mechanically held in compression and not permitted to elongate with the rod, which elongation with its attendant reduction of area would have shown unit stresses in the steel higher than now on record, before the bond would have become broken.

To have been indicative of actual working conditions, the various rods should have been embedded in a unit of concrete, the concrete gripped at each end, pulled apart and stripped from the rods. This could not have shown other than a higher unit stress in the plain rod than was indicated by the method used. In the case of the mechanical bond rod, this would not have been true, as the chemical bond would have been broken when the excess elongation occurred, as would have been the case with the plain rod, thus leaving the mechanical bond rod dependent on its surface projections for its holding strength. The concrete entering between these projections would then have been in shear, while at the same time under a high tensile stress. This, in the writer's opinion, would have caused either a slip in the rod, or more likely, a longitudinal split in the concrete at a stress somewhat lower than was shown by these tests.

The only method, however, that in the writer's opinion shows the true comparative efficiency, is the time-honored method of loading typical beams, reinforced with each type of rod. The results from nearly all such tests tend to bear out the above statements made by the writer.

While the mechanical bond rods show an efficiency generally greater than the plain, the efficiency of the latter is sufficient for many classes of construction. It has its place.

It is desirable, therefore, that the general public be not misled by radical statements of opposing salesmen and place too great weight on their interpretation of the result of scientific tests, which, while interesting, are made under conditions which may perhaps differ materially from those consistent with actual construction work.

EDWARD H. MCCLINTOCK.